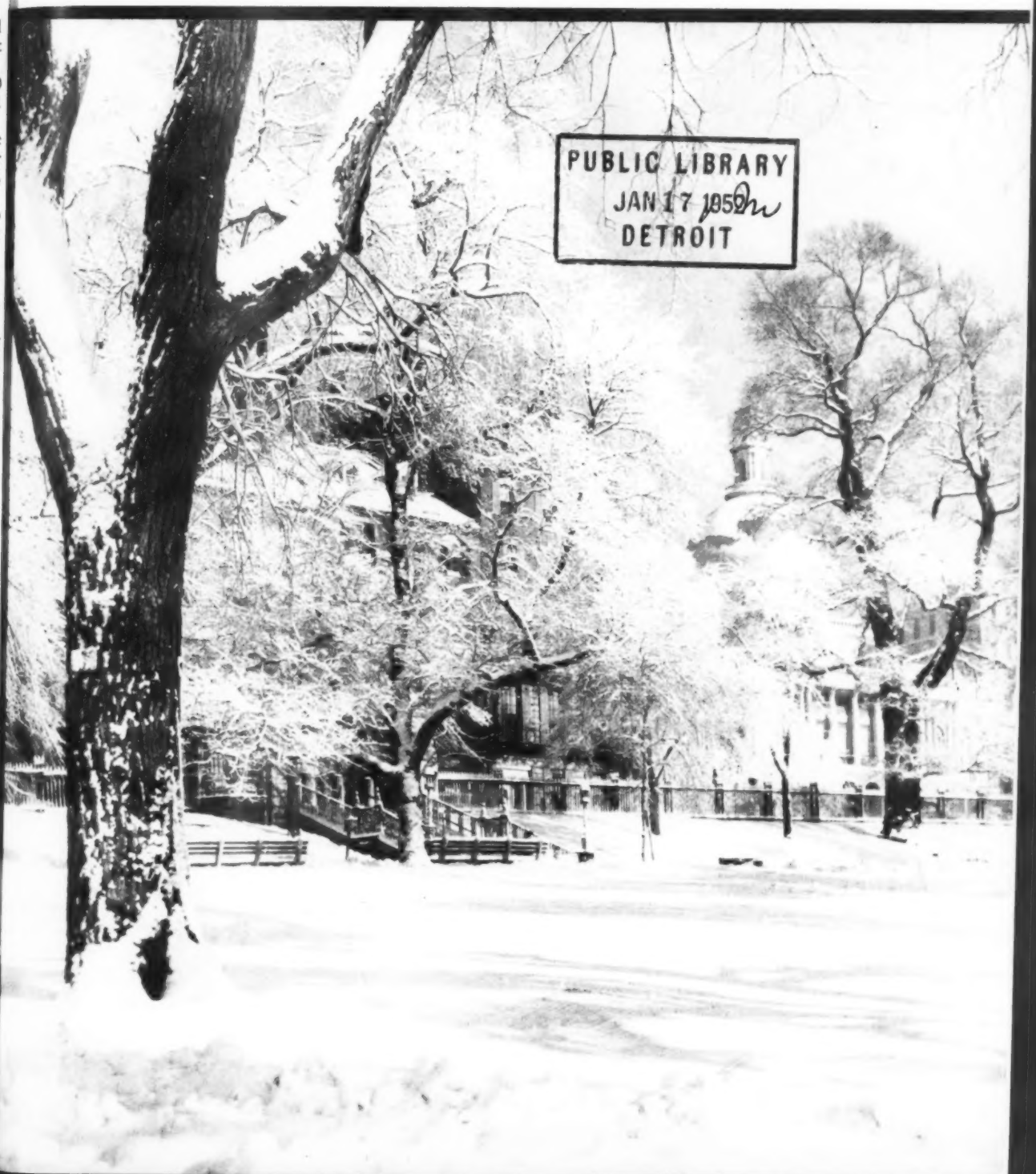
ECHNOLOGY DEPT.

TECHNOLOGY REVIEW

January 1952



PUBLIC LIBRARY
JAN 17 1952
DETROIT

Some of the chemicals being processed in VULCAN-built Plants & Equipment:

ALCOHOLS

Methanol — synthetic
Methanol — from wood distillation
Ethanol — industrial grades from molasses and grain
Ethanol — from sulfite waste liquor
Ethanol — anhydrous, Vulcan process
Ethyl Alcohol — beverage, neutral spirits
Isopropanol
Allyl alcohol
Butanol

ESTERS

Methyl acetate
Ethyl acetate
Butyl acetate
Vinyl acetate
Dibutyl phthalate

ALDEHYDES

Acetaldehyde
Butyraldehyde
Furfural

ETHERS

Ethyl ether
Isopropyl ether

GLYCOLS

Ethylene glycol
Butylene glycol

DDT

KETONES

Acetone
Methyl ethyl ketone

CHLORINATED HYDROCARBONS

Chloroethane
Chlorobenzenes
Chlorotoluenes

ACIDS

Formic acid
Acetic acid — from wood distillation
Acetic acid — from process residues and solvent recovery
Stearic acid
Acetic acid
Propionic acid
Butyric acid

HYDROCARBONS

Butadiene
Heptane
Benzene
Toluene
Styrene
Diphenyl

PHENOLS

Phenol
Naphthol

MISCELLANEOUS

Citronellal
Cottonseed oil
Geraniol
Essential oils
Cellulose derivatives

VULCAN · CINCINNATI

ENGINEERS AND MANUFACTURERS OF PROCESS PLANTS AND EQUIPMENT

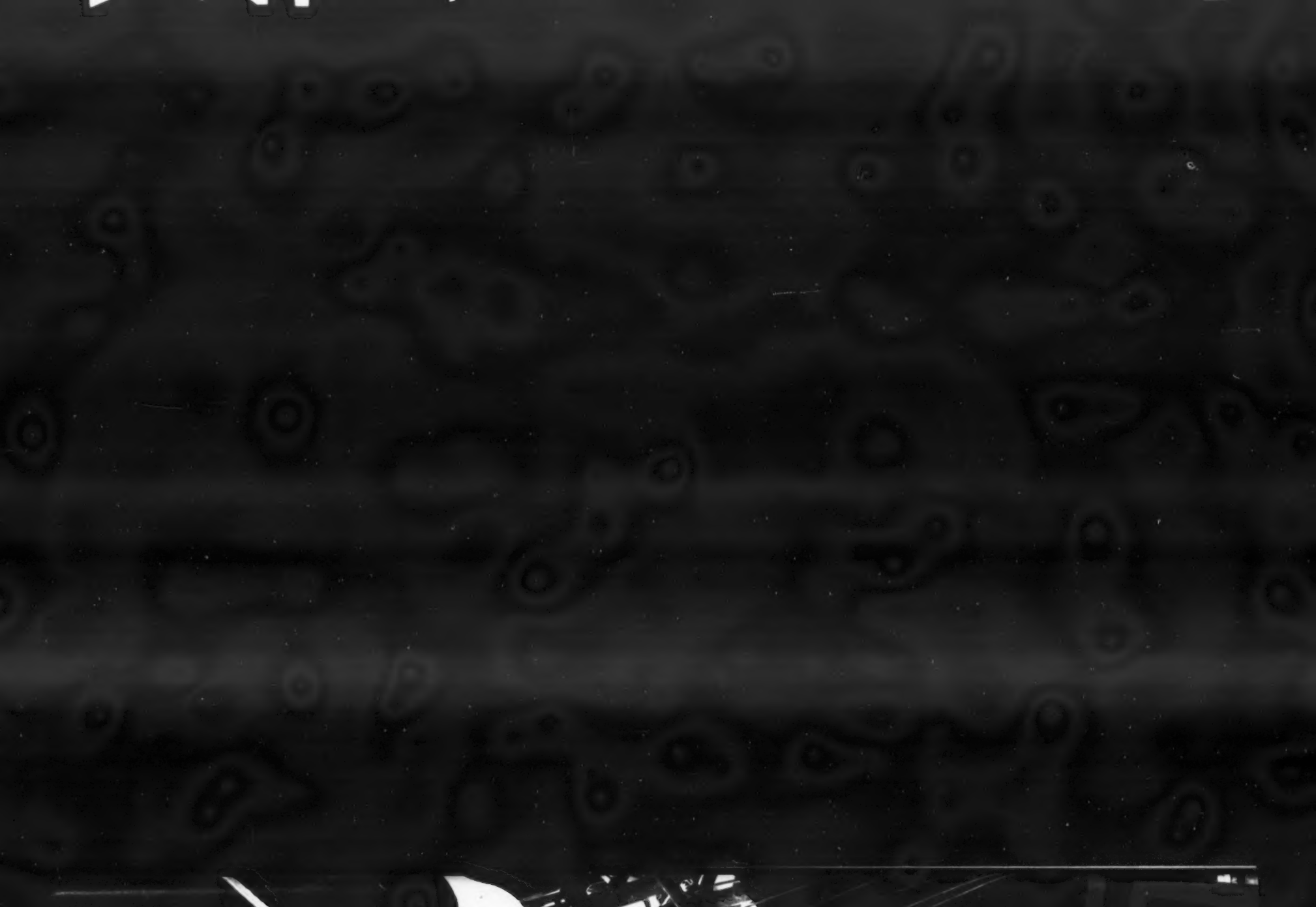
The Vulcan Copper & Supply Co., General Offices and Plant, Cincinnati 1, Ohio

Philadelphia · Boston · San Francisco · Buenos Aires

Victoria Vulcan Process Engineering Co., Ltd., Montreal, Canada

50th Anniversary

1901 1951



TH
Br
$4

All but one of the objects in this picture have something in common. They were affected directly or indirectly by the kind of products Norton and Behr-Manning make. *Can you find the stranger?*

The Shoe Repair Equipment? No! Many operations in a shoe repair shop depend on Norton and Behr-Manning abrasive products. Behr-Manning coated abrasives, for instance, are used to shape and finish heels and soles.

The Submarine? No! Hundreds of its parts depend on Norton or Behr-Manning products. Its camshafts are just one of the many diesel motor parts precision ground by Norton grinding machines and abrasive wheels.

The Greeting Card? No! Norton or Behr-Manning abrasive products are vitally important in manufacturing both paper and printing presses.

Neither Is It the flying wing, the eyeglasses, the washing machine, nor the dentist's equipment.

The stranger in the picture is the bird, which does not rely on man-made products. Remember, any man-made product . . . whether of metal, wood, paper, cloth, leather, ceramics, or plastics . . . depends on abrasives, abrasive products, refractories, or grinding machines that bear such well-known trade-marks as Norton and Behr-Manning . . . world's largest manufacturers of abrasives and abrasive products.

NORTON *Making better products to make other products better* BEHR-MANNING

NORTON COMPANY
MAIN OFFICE AND WORKS
WORCESTER 6, MASSACHUSETTS

ABRASIVES • GRINDING WHEELS • REFRACTORIES
NORBIDE GRAIN AND MOLDED PRODUCTS
GRINDING AND LAPPING MACHINES • NON-SLIP FLOORS

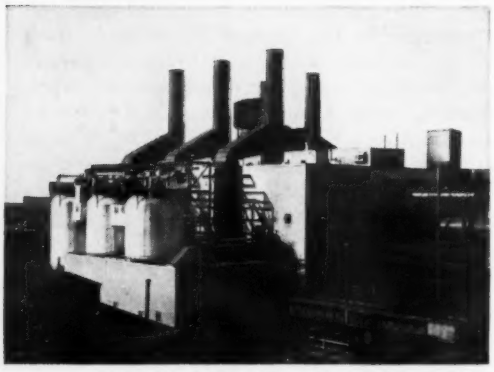
BEHR-MANNING
DIVISION OF NORTON COMPANY
TROY, NEW YORK

ABRASIVE PAPER AND CLOTH • OILSTONES
ABRASIVE SPECIALTIES
BEHR-CAT BRAND PRESSURE-SENSITIVE TAPES

THE TECHNOLOGY REVIEW, January, 1952, Newsstand Edition. Vol. LIV, No. 3. Published monthly from November to July inclusive at Emmett Street, Bristol, Conn. Publication date: twenty-seventh of the month preceding date of issue. Annual subscription $3.00; Canadian and Foreign subscription, $4.00. Entered as second-class matter December 23, 1949, at the Post Office at Bristol, Conn., under the Act of March 3, 1879.

Steam Station at Moss Landing, California, designed and being constructed for Pacific Gas and Electric Company.

WHEN INDUSTRY NEEDS POWER



Central Boiler House and Water Treating Plant for National Tube Division, United States Steel Company

The experience of Stone & Webster Engineering Corporation is available to utilities or industries requiring facilities for steam or electric generation. The work of the Corporation in the steam power station field aggregates in excess of 8,800,000 kw in capacity, equivalent to about 16% of the utility steam generating capacity in the United States.

STONE & WEBSTER ENGINEERING CORPORATION

A SUBSIDIARY *of* STONE & WEBSTER, INC.

GODFREY L. CABOT, INC. produces the greatest quantity and widest range of grades of carbon black of any single producer in the world. Cabot plants extend from Texas, New Mexico, Oklahoma and Louisiana as far as Liverpool, England.

Millions of pounds of Cabot blacks are used each year in the manufacture of paint, varnish, lacquer, plastics and paper products, and for miscellaneous purposes in still other fields of industry.

Perhaps carbon in some form could do or be made to do a certain job for you. Why not write or call **GODFREY L. CABOT, INC.**

77 FRANKLIN ST. BOSTON 10, MASS.

CABOT

SOME PROPERTIES TYPICAL OF CABOT CARBON BLACKS

BRAND	Principal Use	Surface Area M^2 gm*	Particle Diameter (Millimicrons)	Nigrometer Scale (The lower the (blacker)	Volatile Matter %	Grit % Max. (325 Mesh)	Acetone Extract % Max.	Oil Absorption Lbs. 100 Lbs. Black	Tinting Strength % of Sterling S	DPG Adsorption (.001N DPG Solution)	pH Aqueous Sludge	Bulk Density Lbs. cu. ft.
CARBOLAC 1	Paint	1000	10	58	17	.07	0.0	160	155		2.5	5
CARBOLAC 2	Paint	715	14	64	12	.07	0.0	135	155		3.5	6
CARBOLAC 46	Paint	660	14	65	14	.07	0.0	125	155		3.5	6
SUPERCARBOVAR	Paint	400	15	69	5.0	.07	0.0	110	170		5.0	8
MONARCH 71	Paint, Plastics	380	16	71	5	.07	0.0	100	170	60	5.0	10
MONARCH 74	Plastics	300	17	74	5	.07	0.0	95	185	59	5.0	11
SPHERON C	Rubber	230	23	78	4.5	.05	0.0	82		43	4.5	22
ELF 1	Paper	145	24	81	5	.05	0.0	85	184	40	5.0	14
ELF 2	Ink	145	24	81	5	.05	0.0	85	184	40	5.0	11
ELF 3	Ink	145	24	81	5	.05	0.0	85	184	40	5.0	10
SPHERON 4	Rubber	130	24	82	4.5	.05	0.0	80	180	40	4.5	22
SPHERON 6	Rubber	115	25	83	5.0	.05	0.0	80	165	35	4.5	22
ELF 4	Ink	120	26	83	5	.05	0.0	80	180	35	5.0	14
ELF 5	Ink	120	26	83	5	.05	0.0	80	180	35	5.0	11
MONARCH 81	Paint	140	26	81	5	.07	0.0	85	184	45	5.0	12
VULCAN 3	Rubber	65	27	90	0.60	.05	0.15	117	175		9.0	22
ELF 0	Ink	160	29	80	8	.07	0.0	85	180	55	4.5	11
ELF 6	Ink	100	29	85	5	.05	0.0	75	172	32	5.0	14
ELF 7	Ink	100	29	85	5	.05	0.0	75	172	32	5.0	11
ELF 8	Ink	100	29	85	5	.05	0.0	75	172	32	5.0	12
SPHERON 9	Rubber	100	29	85	5.2	.05	0.0	80	160	32	4.5	22
MOGUL SPECIAL	Ink	350	30	80	12	.05	0.0	85	168		4.0	12
MOGUL	Ink	340	32	81	12	.05	0.2	85	165		4.0	12
MOGUL A	Ink	300	34	84	12	.05	0.2	85	165		4.0	12
STERLING 99	Ink	75	39	93	0.90	.05	0.02	70	150		9.5	26
STERLING 10 FLUFFY	Paint	40	41	94	0.8	.03	0.25	115	120		9.0	11
STERLING SO	Rubber	40	41	95	0.80	.05	0.25	136	120		9.0	22
STERLING L	Rubber	34	60	95	0.80	.05	0.2	75	120		9.5	26
STERLING S	Rubber	22	80	100	0.80	.05	0.2	65	100		9.5	26
STERLING NS	Rubber	24	80	98	0.80	.05	0.05	70	110		9.5	26
STERLING V	Rubber	27	51	96	0.70	.05	0.20	98	93		9.1	25

CHECK WITH
RAYTHEON
for Special Purpose TUBES

- ☐ Aircraft Control
- ☐ Hearing Aid
- ☐ Electrometer and GM
- ☐ Long Life Industrial
- ☐ Germanium Diodes and Triodes
- ☐ Ruggedized
- ☐ Guided Missile
- ☐ Special Purpose
- ☐ Subminiatures of all kinds

Raytheon has designed and produced millions of such tubes — has the specialized technical skill and resources to meet your needs. Over half a million Raytheon Subminiatures are carried in stock. Over 300 Raytheon Special Purpose Tube Distributors are ready to serve you. Application engineering service at Newton, Chicago and Los Angeles.

RAYTHEON
RAYTHEON MANUFACTURING COMPANY
Excellence in Electronics
Special Tube Section
55 Chapel St., Newton, Massachusetts

PLAN WITH
DIEFENDORF . . .

On your most difficult gearing problems — let Diefendorf work out your production plans. Competent engineers to analyze every gear requirement. Gears of all types, materials and sizes. Made to specification only.

DIEFENDORF GEAR
CORP.

Syracuse, N. Y.

DIEFENDORF
GEARS

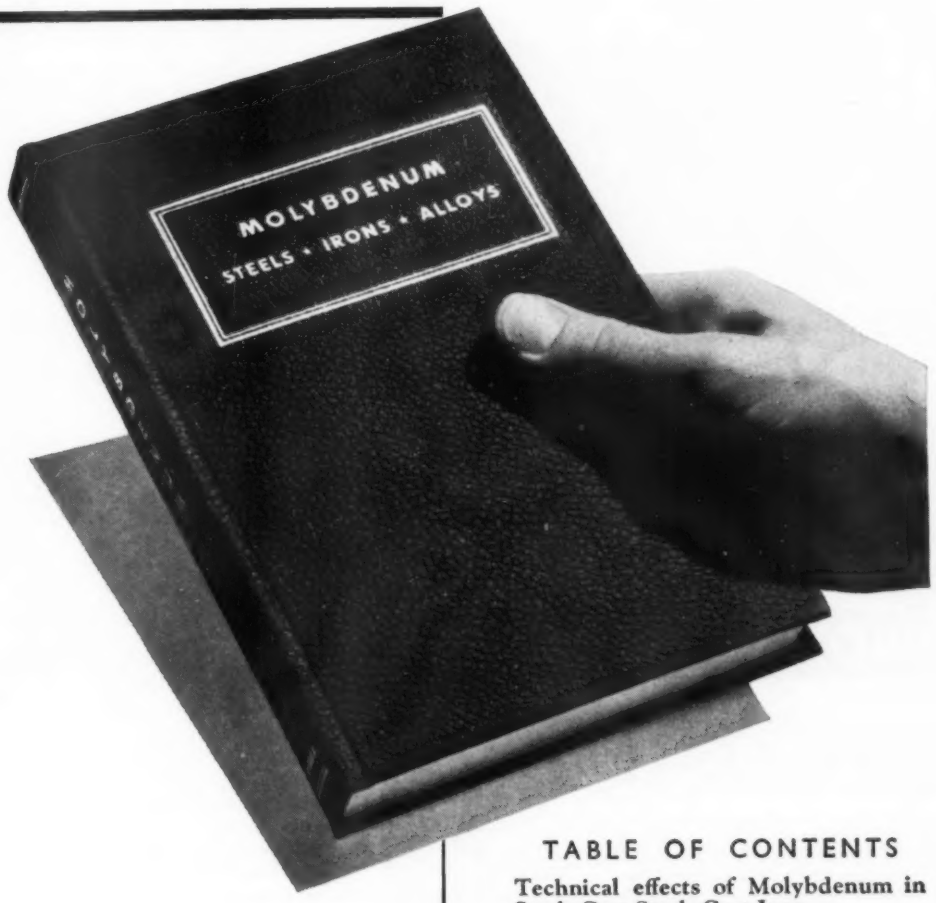
THE TABULAR VIEW

Versatile Windmills. — In principle, at least, helicopters may be traced back to the notebooks of Leonardo da Vinci, but it has been only about a decade that these whirling windmills have assumed practical importance and significance. Its extreme versatility accounts, in large measure, for the rapid rise in popularity of the helicopter, as pointed out by L. WELCH POGUE (page 137) in the first of a two-part article on "The Significance of the Helicopter." Dr. Pogue received the A.B. degree from the University of Nebraska in 1924, the LL.B. degree from the University of Michigan Law School in 1926, and the S.J.D. degree from Harvard Law School in 1927. Following approximately 10 years of general law practice, Dr. Pogue became associated with the Civil Aeronautics Authority, and has since maintained his interests in aviation. Since June, 1946, he has been a member of the firm of Pogue and Neal in Washington, D.C.

Ore Beneficiation. — By artificially inducing radioactivity in minerals and employing the nuclear properties of the elements as a basis for automatic selection, PROFESSOR ANTOINE M. GAUDIN, WILFRED L. FREYBERGER, '47, both of the Department of Metallurgy, and FRANK E. SENFTLE of the Division of Industrial Cooperation at M.I.T., propose (page 143) a new method of ore concentration in "Beneficiation of Ores." ¶ Professor Gaudin received his bachelor's degree from the University of Paris in 1917 and immediately entered Columbia University from which he received the degree of engineer of mines in 1921. He taught at Columbia from 1924 to 1926 and for the next three years was associate professor of metallurgical research at the University of Utah. In 1929 he went to the Montana School of Mines, and, in 1939, came to M.I.T. as Richards professor of mineral engineering. He is author of numerous technical articles and of two books. ¶ Dr. Senftle, a native of Buffalo, received the Ph.D. degree in geophysics from the University of Toronto in 1947. He has been engaged in research in the Metallurgy Department at M.I.T. until recently. He is now in Washington with the Geodetic Survey. ¶ Mr. Freyberger, a native of Newark, N.J., received the S.B. degree from M.I.T. in 1947, and since his graduation has been engaged in research in mineral engineering in projects supported by the Atomic Energy Commission.

Sound and Light. — Among the more powerful aids to research in communication and linguistics are methods for analyzing and synthesizing sound by means of visible speech films. A brief description of a sound analyzer and synthesizer for speech films is given (page 145) by FRIEDRICH VILBIG. Born on April 24, 1903, Dr. Vilbig received his master's and doctor's degrees from the Technical University in Munich. He is author of approximately 50 technical papers, in addition to *Lehrbuch der Hochfrequenztechnik*. Since 1948 he has worked at the Cambridge Air Force Research Center on speech and communication problems.

For metallurgist and engineer . . .



This 400pp. book describes the varied applications of Molybdenum as an alloying element in a wide range of materials. It presents the fundamentals which must guide the selection of the most suitable alloys for specific applications.

Much recent information is included, some of it hard to find elsewhere. About 500 references to technical literature facilitate further reading, and there are 187 diagrams and 91 tables.

The book is available free on request by metallurgical and engineering students.

Climax Molybdenum Company
500 Fifth Avenue · New York City

C16

TABLE OF CONTENTS

Technical effects of Molybdenum in Steel, Cast Steel, Cast Iron.
Fundamental Effects of Heat Treatment on Microstructure.
Addition of Molybdenum.
Wrought Alloy Engineering Steels—Medium, Low, High Carbons; Low Temperature Properties, Machinability.
Wrought Corrosion Resistant Steels.
Wrought Steels for Elevated Temperature Service.
Tool Steels. Steel Castings. Cast Iron.
Special Purpose and Nonferrous Alloys.

Please send me "Molybdenum: Steels, Irons, Alloys".

NAME .....

STATUS .....

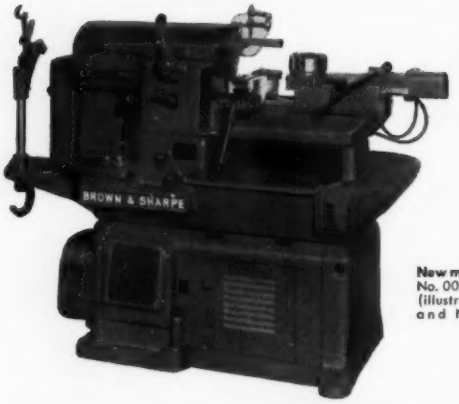
ADDRESS .....

.....

TR.1 .....

MOLY

Here's top efficiency for short-run jobs!



New models: No. 00, No. 0 (illustrated), and No. 2

Three new-design Brown & Sharpe Hand Screw Machines do basically the same type of work as their equivalent model numbers in the automatics. But, on short-run jobs, *they do it more efficiently!* They're set up more rapidly . . . require no cams or timing for automatic functions. Designed with advanced efficiency features throughout, including full anti-friction-bearing spindles. Write for detailed literature. Brown & Sharpe Mfg. Co., Providence 1, R. I., U. S. A.

BROWN & SHARPE BS

DC-AC CHOPPER

A model for every use — 60 and 400 cycles
Single pole and double pole — Make-before-break contacts — Contacts in air or in liquid

These Choppers convert low level DC into pulsating DC or AC, so that servo-mechanism error voltages and the output of thermocouples and strain gauges may be amplified by means of an AC rather than a DC amplifier. They are hermetically sealed, precision vibrators having special features which contribute to long life and low noise level.

WRITE FOR CATALOGS . .
#246B, 60 cycles, AC
#280, 400 cycles, AC

STEVENS-ARNOLD
INCORPORATED
22 ELKINS STREET, SOUTH BOSTON 27, MASS.

MAIL RETURNS

Laurels for Lowell

FROM JAMES L. TRYON:

For the admirable article in the December, 1951, issue of The Review on "The Lowell Institute School," I want to send my appreciations. It is one of the most informing and interesting articles on education I have ever read.

The School has been a wonderful benefit to ambitious and industrious men. It was original in its conception and has been fortunate both in its trustees and its directors, who have co-operated in carrying out the intention of its founder and added to its offerings as time has gone on.
Medford 55, Mass.

Engineers as Envoys

FROM LLOYD F. HUNT:

After traveling many miles in Sweden, I read with interest "Study in Sweden" by Messrs. Hill, Randall, and Schotland in the February, 1951, Review.

"Study in Sweden" is very well written and represents conditions just as we found them in Sweden. I am satisfied that if peace is to be accomplished it will be done by our engineers, as they look at facts, and facts are common in all countries and languages. It is a very important part of this goal to have a great deal more interchange of engineering talent between nations.
Los Angeles 53, Calif.

Erroneous Ersatz

FROM ERB N. DITTON, '22:

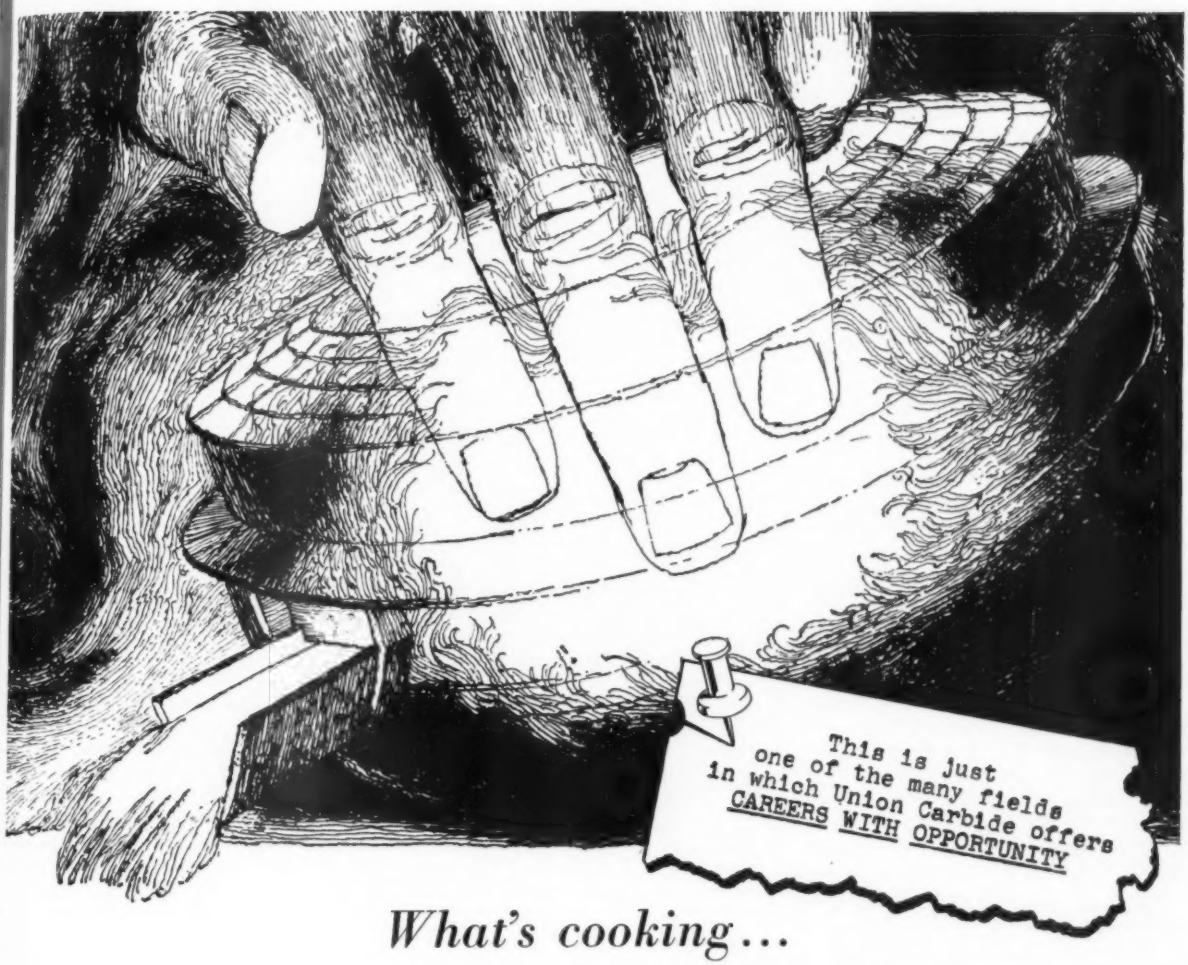
I was very much surprised to note certain statements in the article "Wool Extenders" on page 13 of the November, 1951, issue of The Review.

This article contains the statement, "To an increasing extent the ersatz fibers are also being used as blending agents in wool." I certainly would question the use of the word "ersatz" in describing the newer synthetic fibers. These fibers have certain very definite properties of their own and can stand on their own merits. They may be used as wool substitutes in certain cases, or as the article states, be blended with wool, and are certainly not ersatz fibers.
New York 16, N.Y.

Goodyear Tire & Rubber Co.

Today, you need a builder whose many years of specializing in industrial construction has established dependable sources of critical materials —and whose organization has the know-how to build efficiently under war conditions.

W. J. BARNEY CORPORATION
FOUNDED 1917
101 PARK AVENUE, NEW YORK
INDUSTRIAL CONSTRUCTION
Alfred T. Glassett, '20, President



What's cooking...

From the raging heat of this furnace come basic materials for your stainless steel kitchenware, plastic shower curtains, and man-made textiles

What's cooking in the seething, roaring fire of this electric arc furnace?

The fingers? No! They represent what's doing the cooking.

WHITE-HOT INFERNO—In the actual furnace the fingers are giant rods of carbon or graphite, called electrodes, that carry the heat-creating electricity. Carbon and graphite are the only materials that can do this and stand up under the terrific temperatures of 6,000 degrees or more.

In carbon arc furnaces, alloy metals used in producing stainless steel are separated from their ores. Similar furnaces are used to make other tough and hard varieties of fine steels for automobiles, airplanes and many other familiar products.

SERVES YOU MANY WAYS—But steel making is only one important way in which carbon and graphite serve you. Motion picture screens are illuminated by the brilliant light of the carbon arc. Calcium carbide, the source of many modern plastics, textiles and chemicals is an electric furnace product. Without carbon we wouldn't have dependable, long-life dry batteries for flashlights, radios and hearing aids.

WORK OF UCC—Creating carbon and graphite products for an almost endless number of uses is one of the many accomplishments of the people of Union Carbide.

STUDENTS and STUDENT ADVISERS

Learn more about the many fields in which Union Carbide offers career opportunities. Write for the free illustrated booklet "Products and Processes" which describes the various activities of UCC in the fields of ALLOYS, CARBONS, CHEMICALS, GASES, and PLASTICS. *Ask for booklet N-2.*

UNION CARBIDE
AND CARBON CORPORATION

30 EAST 42ND STREET UCC NEW YORK 17, N. Y.

UCC's Trade-marked Products of Alloys, Carbons, Chemicals, Gases, and Plastics include

NATIONAL Carbons • ACHESON Electrodes • ELECTROMET Alloys and Metals • HAYNES STELLITE Alloys
PREST-O-LITE Acetylene • LINDE Oxygen • PYROFAX Gas • SYNTHETIC ORGANIC CHEMICALS
EVEREADY Flashlights and Batteries • PRESTONE and TREK Anti-Freezes • BAKELITE, KRENE, and VINYLITE Plastics

What GENERAL ELECTRIC People Are Saying

G. A. RIETZ

Educational Service Division

PROBLEMS FACING ENGINEERING AND SCIENCE STUDENTS: We are experiencing a growing appreciation of the importance of an adequate supply of well-trained engineers and scientists to this country's immediate and future welfare. And, although this situation creates for science and engineering students such as you excellent opportunities for future employment, it also leaves you plagued by confusion and uncertainty. No doubt you find yourselves searching for the answers to many questions: "Why should I study?" "Should I continue my education or enlist for military service?" "Should I even bother talking to industrial recruiters who visit the campus?"

No one can deny that these are uncertain times. But no one period can truthfully be called normal. The young student or graduate in 1917, 1929, 1937, or 1941 had hard problems to face, too. Life is made up of problems. There is nothing unique in your position.

It is not certain that military service will interrupt your schooling. If it should, however, remember this: You, as college graduates, will normally expect to pursue your individual occupations for something in excess of forty years. Productive work is, then, a lifetime proposition. All your schooling has been a preparation for this. A period of two, or even five, years of service would represent a relatively small portion of your total professional life. It wouldn't seem wise, then, to allow such a brief interruption to prompt unwise decisions that will affect your entire future.

I suppose good advice is a commodity of which there is a surplus, and therefore, you may not be inclined to take it seriously. I'm aware, too, that Socrates' life was ended by the poison cup, and he was a giver of advice. However, I'll chance it. The following advice parallels closely that being given by well-informed fathers to perplexed sons in school.

Pursue your studies. Go as far as possible in your chosen field, Don't, because of uncertainty or despair, abandon your studies. Should it become necessary for you to serve in the armed forces, the odds are predominantly in favor of your returning to civil and professional life after a relatively short period. It will be far easier for you to pick up the traces of study than to start from scratch, and you will have the jump on others who were not so wise.

As graduation approaches, discuss job opportunities with many industrial and other recruiters who visit the campus. As a result of these interviews, you might become a permanent employee with promise of uninterrupted service in a company of your choosing. Should your employment be interrupted by military service, you will usually have a company and a job to return to. If you should go into service before employment, at least you will have the advantage of having your record on the books of a number of companies, awaiting your return and reapplication for work.

Now, where does General Electric stand on the employment of people like you in these times? Regardless of Reserve or Selective Service status, we want to interview all students who wish to see us. And, regardless of status, we will make job offers to those young men and women we would like to have as members of the General Electric family.

Should any of these people be called into the service before reporting to us for work, our offers will still be waiting for them on their return.

Barring an exceptional, and unforeseen, military situation of such long duration that an abnormal accumulation of commitments does not permit us to meet the last ones made, those men and women already with us before being called for military service will maintain continuity, and will be assured of employment upon return.

We didn't have to go back on a single commitment following World War II. We trust we will never have to.

Kansas State College
Manhattan, Kansas
October 11, 1951

★

E. S. LEE

General Electric Review

MEASUREMENTS UNIVERSAL: World understanding through scientific discoveries, engineering achievements, and measurements has forever been prominent.

Beginning with January 1, 1948, the electrical industry discarded the mercury ohm and the silver voltameter, and replaced them with length from light, with mass from the attraction of the earth, and with time from the movement of the stars. This was an outstanding contribution by the National Standardizing Laboratories of the great nations of the world and was the culmination of over forty years of the finest of measurements and measuring technique. And in this the scientists and engineers of our own United States National Bureau of Standards were leaders. We can be proud of their accomplishments.

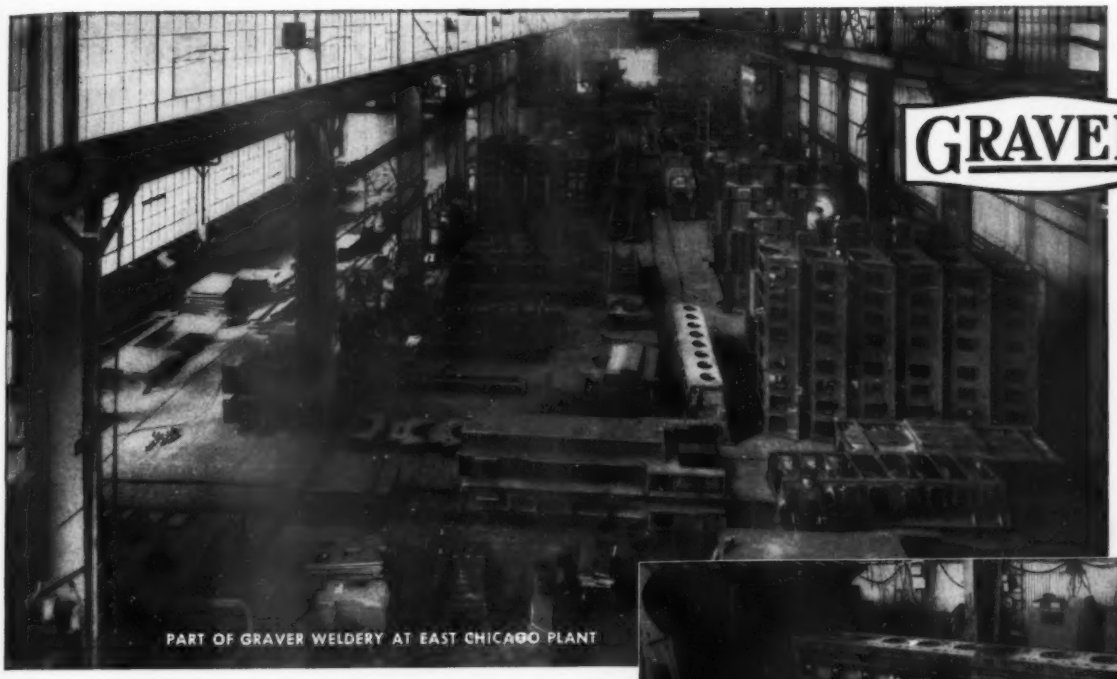
And we are glad to recognize the engineers and scientists in General Electric Company who see in measurements the continuing opportunity for making available new knowledge to give certainty to product design and manufacture. This is the role of measurements in industry. Of their fundamental need there is no end.

G-E Review

November, 1951

You can put your confidence in—

GENERAL ELECTRIC



PART OF GRAVER WELDERY AT EAST CHICAGO PLANT

WELDMENTS

in a wide range

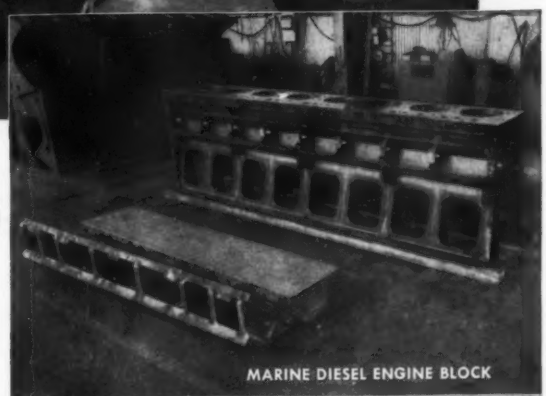
by GRAVER

Manufacturers in the heavy industries field have for many years found Graver an excellent source for welded subassemblies. From Graver's well-equipped weldery has flowed a continuous succession of weldments for a wide range of industries. Pictured are examples of recent Graver work . . . mass-produced but expertly fabricated . . . with the special advantages secured through subcontracting to Graver: economy in cost, rigid quality controls, creative engineering and sound welding research.

GRAVER TANK & MFG. CO., INC.

EAST CHICAGO, INDIANA

NEW YORK • CHICAGO • PHILADELPHIA • WASHINGTON
DETROIT • CINCINNATI • CATASAUQUA, PA.
HOUSTON • SAND SPRINGS, OKLA.

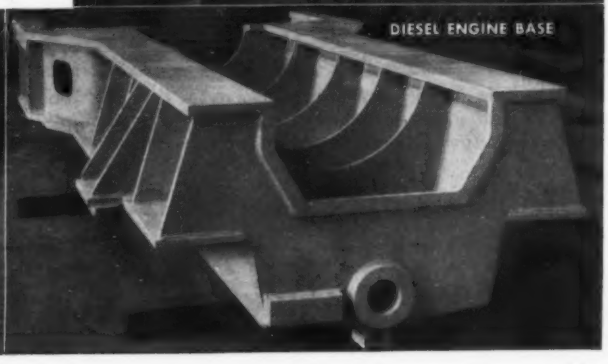


MARINE DIESEL ENGINE BLOCK

LADLES FOR MOLTEN METAL

LEAD POT

TIN POT



DIESEL ENGINE BASE

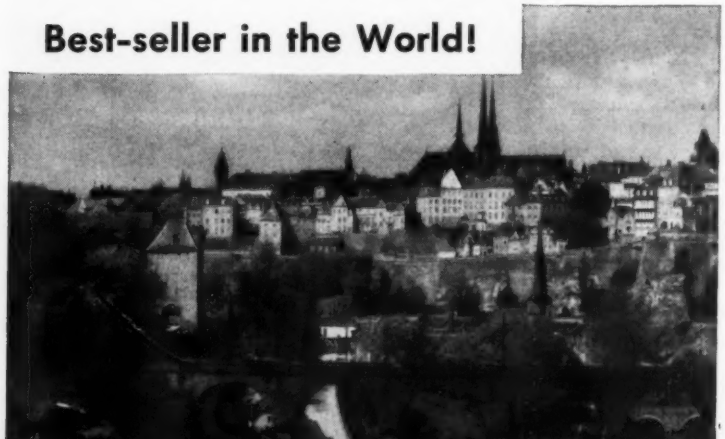
Best-seller in Detroit!

Car makers *know* tires—and use more Goodyear Super-Cushions than any other tire. They've found they're tops in not just *one*, but *three* ways—for *safety*, for *comfort*, for *mileage!* (Above: Washington Blvd., Detroit, Mich.)

Best-seller in America!

Car owners who drive *billions* of miles yearly buy more Goodyear Super-Cushions than any other low-pressure tire! They've found no equal to Goodyear's triple value of safety, long mileage, and soft riding. (Mt. Rose, Nev.)

Best-seller in the World!



More people *the world over* ride on Goodyear tires than on any other kind! *Doesn't it stand to reason that the tire that gives the most people the greatest satisfaction is the tire for you to buy?* (Above: Luxembourg from Rue de Trèves.)

More people ride on Goodyear tires than on any other kind

Super-Cushion by GOODYEAR

Super-Cushion, T. M.—The Goodyear Tire & Rubber Company, Akron, Ohio

Lil and Al Bloom from Black Star

"Would you cash this check for me, please?"

THE TECHNOLOGY REVIEW

TITLE REGISTERED, U. S. PATENT OFFICE

EDITED AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

CONTENTS *for January, 1952* **Vol. 54, No. 3**

WINTER ON BEACON HILL • *Photograph by Raymond E. Hanson* ... THE COVER

TECHNOLOGICAL SPIRES • *Photograph by Ward Allan Howe* . . . FRONTISPIECE 132

THE SIGNIFICANCE OF THE HELICOPTER .... By L. WELCH POGUE 137

The versatility of the small helicopter is discussed in the first installment of a two-part article

BENEFICIATION OF ORES ..... By ANTOINE M. GAUDIN, FRANK E. SENFTLE, and WILFRED L. FREYBERGER 143

Artificially induced radioactivity, employing the nuclear properties of elements found in each mineral, is under investigation as a means of mineral separation

SPEECH AND COMMUNICATION PROBLEMS By FRIEDRICH VILBIG 145

Visible speech films, for recording and transcribing sound, provide an effective method of research in the communication and linguistic fields

THE TABULAR VIEW • *Contributors and Contributions* 124

MAIL RETURNS • *Letters from Review Readers* 126

THE TREND OF AFFAIRS • *News of Science and Engineering* 133

THE INSTITUTE GAZETTE • *Relating to the Massachusetts Institute of Technology* 147

Editor: B. DUDLEY

Business Manager: R. T. JOPE

Circulation Manager: D. P. SEVERANCE

Editorial Associates: PAUL COHEN; J. R. KILLIAN, JR.; WILLY LEY; F. W. NORDSIEK; J. J. ROWLANDS

Editorial Staff: RUTH KING; BEATRICE D. WRIGHT

Business Staff: EILEEN E. KLIMOWICZ; MADELINE R. MCCORMICK

Publisher: H. E. LOBDELL

Published monthly from November to July inclusive on the twenty-seventh of the month preceding the date of issue, at 50 cents a copy. Annual subscription, $3.50; Canadian and foreign subscription, $4.00. Published for the Alumni Association of the M.I.T.: Alfred T. Glassett, President; H. E. Lobdell, Executive Vice-president; Hugh S. Ferguson, Allen Latham, Jr., Vice-presidents; Donald P. Severance, Secretary-Treasurer. Published at Hildreth Press, Inc., Bristol, Conn. Editorial Office, Room 1-281, Massachusetts Institute of Technology, Cambridge 39, Mass. Entered as second-class mail matter at the Post Office at Bristol, Conn. Copyrighted, 1952, by the Alumni Association of the Massachusetts Institute of Technology. Three weeks must be allowed to effect change of address, for which both old and new addresses should be given.

Ward Allan Howe

Technological Spires — as seen through Brooklyn Bridge steel tracery

THE
TECHNOLOGY
REVIEW

Vol. 54, No. 3 January, 1952

The Trend of Affairs

Happy New Year

THE old custom of reviewing progress of the old year and looking, forever hopefully, toward the potentialities of the new, takes on renewed significance this month as we are able to assess events of the first year of the second half of the Twentieth Century.

As recorded in President Killian's annual report, during 1951, M.I.T. has:

1. Successfully concluded its $20,000,000 Development Fund campaign.
2. Completed construction of the Hydrodynamics Laboratory and Ship Model Towing Tank.
3. Created a School of Industrial Management.
4. Elevated the Division of Humanities to the School of Humanities and Social Studies.
5. Revised the curriculum of several of its courses.
6. Taken an important step toward making the Institute a residential college by converting the Riverside Apartment Hotel into Burton House, a student dormitory.
7. Greatly extended the scope and variety of subjects offered during the Summer Session.
8. Begun construction on the Sloan Metals Processing Laboratory and the John Thompson Dorrance Laboratory for Biology and Food Technology.
9. Obtained an official residence for the Dean of Students.
10. Created the Office of Publications.
11. Established counseling activities for preparatory students who expect to attend M.I.T.
12. Begun work on a Faculty Club.

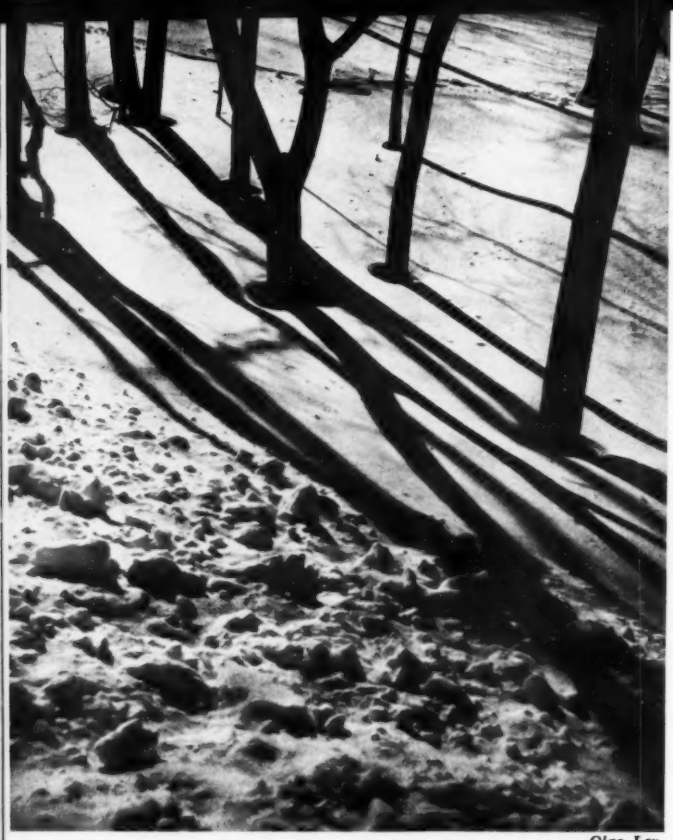
In addition to these major achievements, many minor ones have added to the effectiveness of teaching, research, or administration activities at Technology.

As for the products which M.I.T. turns out, the demand for all technically trained personnel continued high. In certain fields (such as physics, electronics, aeronautical engineering, and mechanical engineering, for example) the shortage of man power has been extremely acute. Production and wages were high throughout the year. So too were taxes which, along with prices, reached unprecedented peacetime heights. But as taxes, prices, and wage rates spiraled ever upward, the ordinary citizen was likely to find the purchasing power of his "take-home pay" diminishing ominously.

Especially during the last few months of the year, large numbers of public officials suffered from ill health as epidemics of Potomac poisoning, mink anaphylaxis, and tax scandalitis swept the country from coast to coast. Apparently, all three diseases are closely related occupational hazards of, and may even be endemic to, political appointees. Because modern protective measures are unusually effective, symptoms are not readily detected in the early stages and the maladies are seldom politically fatal, except possibly quadrennially.

In Korea, almost the entire second half of the year was spent in futile armistice talks while the enemy built up his reserves of air- and man-power. At the time of writing, hostilities have come to a virtual standstill. Korea has not been unified under its own free rule, as was originally stated to be the United Nations objective. Instead, since December, 1950, nearly all of North Korea has been lost to the enemy. Since the beginning of the Korean "police action" the United States has suffered more than 101,000 casualties, of whom more than 17,000 have made the supreme sacrifice. Possibly one third of these fatalities may be accounted for as prisoner-of-war murders by an enemy whose face it is necessary to save.

The peoples of the world sorely desire peace, but this is not the greatest need. There can be no peace worthy of the name without mutual trust and confidence, without respect and integrity, without honesty and high moral principles, without culture and a return to religious precepts. These are the things to work for if 1952 is to be a happy new year.



Olga Ley

In the Trend of Affairs section last month, there was published an unidentified photograph of a peacetime vehicle bearing a strong resemblance to a cannon. Our promise to eliminate any additional guessing is hereby fulfilled by revealing that the apparatus shown on page 78 of the December, 1951, issue is a huge concrete mixer of unusual design, towed by a Diesel-powered, two-wheeled prime mover. Approximately seven cubic yards of concrete can be mixed in its 34-foot barrel en route to a construction site. The machine can traverse rough terrain and discharge concrete at a height of 20 feet.

Radioactive Water Supplies

DISCHARGE of radioactive wastes by the large, new atomic energy industry, together with the effluents which may be forthcoming with the projected expansion of industries utilizing nuclear energy, has given rise to a new type of stream pollution. Added to the normal peacetime activities of the industry is the ubiquitous prospect of warfare with atomic weapons and radiological agents. Because a safe water supply is essential to safeguard public health, the waterworks engineer must be prepared to cope with problems of radioactive contamination of water supplies.

The ideal goal of the atomic energy industry is that no radioactive substances be released from its installations. This is a standard which is impossible to attain and, in the future, may not be feasible to approach economically. It is apparent that the wastes of the atomic energy industry present a far-reaching problem that will not permit a period of procrastination, such as has prevailed during the development of our current stream pollution conditions with liquid wastes from industry.

Anticipating the need for early solutions to this important problem, studies on the removal of radioisotopes by water treatment processes have been in progress in the Sedgwick Laboratories of Sanitary Science at M.I.T. in a research project sponsored by the Atomic Energy Commission. Under the direction of Rolf Eliassen, '32, Professor of Sanitary Engineering, the program was conducted by John B. Nesbitt, '49, a research assistant, and former research assistants Warren J. Kaufman, '47, and Morton I. Goldman, '50, of the Department of Civil and Sanitary Engineering.

The problem of the removal of radioisotopes from water is essentially one of the selective removal of specific elements present in ionic form when these elements include a sufficient number of radioactive species to constitute a radiological health hazard. The problem must be studied by a consideration of the basic sciences as well as by pilot plant applications to substantiate techniques developed from fundamental research. In the program of research at the Institute, radioactive phosphorus, as orthophosphate, was selected for the required studies because of its widespread use in tracer applications and because it may be produced in reactor cooling waters high in sulfates. Alum and ferric sulfate were studied as agents for coagulating radioactive ions, while clays were employed to simulate natural turbidities and also to serve as coagulant aids. Three typical surface waters were synthesized for the detailed study: a soft New England water, a Midwest water of good coagulating characteristics, and a hard water enabling the use of a softening process. Tests of the removal of orthophosphate by coagulation were made on each type of water under a variety of turbidities and coagulant dosages, and pilot plant runs were made on Ohio River water.

The tests indicate that conditions which gave excellent removal of phosphate, gave only fair removal of strontium and no removal of iodine. This emphasizes the fact that the removal of radioactivity from water depends upon the chemical or ionic form in which that radioactivity appears. The coagulation process is the major mechanism involved in the removal of radioactive phosphate from water. Clays were found not to bring about appreciable removal of phosphorus unless used in conjunction with hydrolyzing coagulants. Strontium, and other multivalent cations are best removed by coagulation processes yielding negatively charged floc particles such as are encountered in lime-soda softening or phosphate-lime coagulation. In all runs the removal of radioactivity was found to exceed 99 per cent.

From research conducted thus far, it is clearly evident that effective means of safeguarding public water supplies against radioactive contamination is economically feasible through suitable water treatment. The type of treatment for optimum removal of radioactivity depends upon the form in which radioactivity is present.

Oh Schwa!

ANYONE who attempted to pronounce the English language as it is spelled would be largely unintelligible. Moreover, one who gives each English word only one pronunciation, regardless of the context, renders the appearance of affectation or of limited familiarity with the language. Many English words have more than one accepted pronunciation; some may correctly be said in a number of ways.

The wide variations in accepted English pronunciation are related not only to regional usages and degree of formality of the speech, but also to the rhythms and accents of the phrase in which the word occurs. Some of the variations in pronunciation are not given in regular dictionaries, but all may be found in specialized lexicons, such as *A Pronouncing Dictionary of American English* by John S. Kenyon and Thomas A. Knott.*

Much of the variability in pronunciation of a given word arises from a strong tendency of some English vowel sounds to lose their individuality, and to be replaced by a neutral sound which phoneticians call the "schwa." This sound, produced by expulsion of breath with the vocal organs in a generally relaxed position, decidedly resembles a grunt or groan. The schwa occurs frequently in even the most precisely spoken English. For example, the vowels of "above" can be pronounced in no other way. If the reader will say this word aloud, he can satisfy himself that both the *a* and the *o* are pronounced with the equivalent of a grunt.

But in good English, spoken in informal and conversational situations, the schwa supplants more and more vowels. As a random example, take the phrase, "Massachusetts Institute of Technology." When these words are pronounced with utmost formality, the schwa appears as the second *a* of "Massachusetts" and as the *o* in "of." But in flowing colloquial speech, the schwa occurs in three additional places: the *e* of "Massachusetts," the second *i* of "Institute," and the second *o* in "Technology." Thus, if we print an asterisk for the schwa sound, the colloquial pronunciation of this phrase is "Mass*chus*tts Inst*tute *f Technol*gy."

Such free use of the schwa does not endanger intelligibility, as the consonant framework of many words identifies them fully and the context makes meanings clear. In fact, easy speech with liberal use of the schwa sound has acceptance today as the standard for radio and the stage.

These observations bring to mind a recent article in the scientific press describing a group of Bushmen who inhabit the fringes of the Kalahari Desert in Africa. The language of these people is described as consisting mainly of clicks made with the tongue against the roof of the mouth. Such speech is considered to be the most primitive known form of human communication. Although the English-speaking person employs clicks only in addressing horses or other animals, it is striking to note the predominance in current American speech of a similarly rudimentary sound – the schwa.

* Springfield: G. and C. Merriam Company, 1944. $3.00.

High Temperature, High Stress Alloys

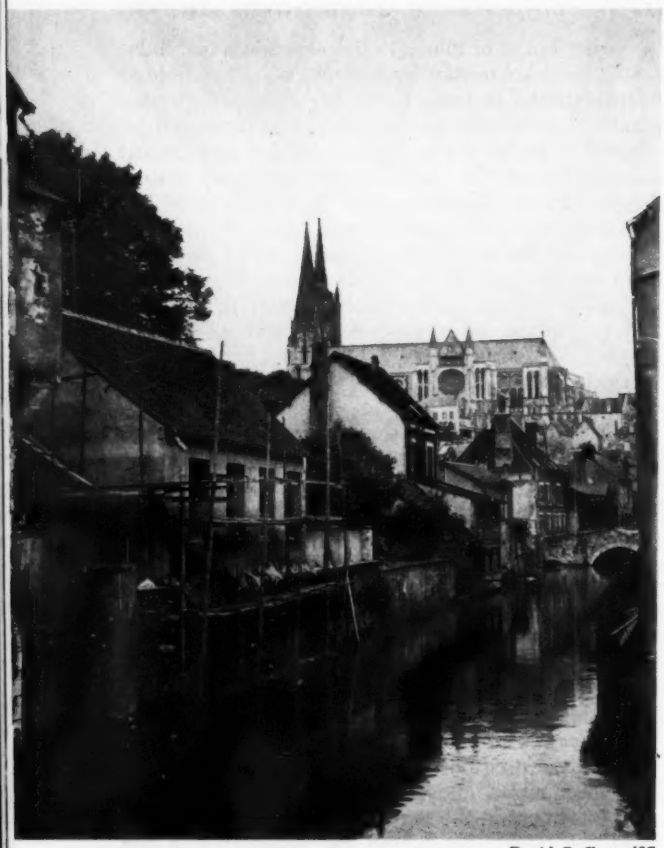
A WIDE range of alloys in the chromium-molybdenum-nickel ternary system may be susceptible to heat treatment to make better high-stress, high-temperature parts, such as those in gas turbines and jet engines. A recent study of alloys has led to a critical examination of the chromium-nickel binary system diagram by the Department of Metallurgy at M.I.T. This was necessary as structures which were being obtained in the ternary system could not be predicted from examination of the binary-phase systems. It is anticipated that chromium-molybdenum-nickel alloys may permit the use of temperatures as high as 1,800 degrees F. in gas turbines, as compared to the present level of about 1,500 degrees F. based on the use of cobalt base alloys.

It has now been established that chromium undergoes a transformation in its crystal structure about 100 degrees below its melting point, which is about 1,930 degrees C. At the temperature of transformation (1,830 degrees C.), chromium changes from a high-temperature, face-centered cubic structure to the established low-temperature, body-centered cubic structure. The Cr-Ni phase diagram under these circumstances changes from that of a simple eutectic system to a system containing both a eutectic and eutectoid transformation, the eutectoid temperature being about 1,180 degrees C., with a eutectoidal composition of 63 per cent chromium and 37 per cent nickel. One of the interesting possibilities is that a wide range of chromium-nickel alloys may now be susceptible to heat treatment in the same sense that steels are.

In this work, conducted by Nicholas J. Grant, '44, Associate Professor of Metallurgy, and David S. Bloom, '47, a research assistant in the Department of Metallurgy, it has already been determined that martensitic-type structures can be obtained by quenching from above the eutectoid temperature.

The research program described above was conducted under the sponsorship of the Bureau of Aeronautics of the Navy Department.

Irwin Fait



David R. Knox, '27

The spires of Notre Dame de Chartres, or Chartres Cathedral, as it is more commonly known, located in the city of Chartres, France

Shoes That Walk for You

By David O. Woodbury

It is widely said that there has been no basic improvement in the design or principle of shoes since Julius Caesar invented hard heels for the boots of his soldiers. This 2,000 years of stagnation in footwear, however, has apparently come to an end in a new type of shoe, currently being perfected in the Department of Physical Education of the University of Southern California. The new shoes, called "ripple soles," give every promise of having demonstrated an entirely new principle in walking – a principle which cuts down the shock of ground contact by 40 per cent, lengthens the normal stride by six inches, and makes walking a much easier and more invigorating exercise.

The ripple sole shoe is exactly what the name implies. To the standard flat sole of an ordinary shoe is affixed an extra sole of composition rubber, folded into corrugated form, so that the wearer stands on a series of waves which have a considerable amount of spring. The waves are about three quarters of an inch high and are spaced an inch or so apart, from heel to toe. The ripple sole is bonded to the flat sole by cement, and is held permanently in place.

As the wearer steps forward, his heel strikes the ground first, as with common footwear. But instead of the sharp unyielding blow upon the pavement, the kinetic energy of the mass of the foot and shoe is taken up by the first wave of the ripple. The sole then distorts, absorbing the energy and eliminating the shock. An instant later, the next ripple picks up the load and distorts in the same manner, while the first ripple advances the foot slightly, as if it were hinged to the ground. The energy stored in the first ripple begins to flow back into the foot, propelling it forward. This action continues from ripple to ripple, till the toe leaves the ground. The combined effect is somewhat like walking on a special kind of roller skates, except that there is no factor of instability.

The ripple sole shoe came about by chance during the early part of 1951. A retired orthopedic shoe specialist, Nathan Hack, was doing unpaid experimental work for the Department of Physical Education at the University of Southern California, when a research problem in shoes came into the laboratory from the United States Army. This problem was to devise a shoe for parachute troops which would break the shock of landing, and cut down the high incidence of foot and leg injuries characteristic of this military operation. The problem came to the University because Laurence E. Morehouse, research professor in physiology there, had done brilliant work for the Air Corps in combat physiology during World War II.

Morehouse and Hack tackled the paratrooper problem together, with Hack suggesting possible designs for the new shoe. Their first attempt was to fit a shoe with springs. The method of test was to have their laboratory assistants jump off a table onto a hard floor, stiff-legged – a method capable of giving a 12G. shock to the legs and body.

Hack's ripple-sole design came along after a number of trials, but it was not particularly successful in solving the problem in hand. During the tests, however, a number of the jumpers would walk around the room, awaiting their turns. To their amazement they discovered that the shoes gave them a totally new sensation in walking; they described it as like "walking on air."

The designers saw at once that they had hit upon an interesting new principle for general footwear. Dropping the Army tests temporarily, they began a series of studies of walking with the new shoe, analyzing the action of the soles with high-speed motion pictures and elaborate thrust and impact measurements which the laboratory was specially equipped to make. Results were so startling that the design was perfected and a patent obtained on it.

The new ripple sole shoe has lately been brought to the attention of the shoe industry and has resulted in many requests for manufacturing contracts. The shoe, Hack believes, has many valuable applications, especially for occupational wearers, such as postmen, policemen, watchmen, barbers, dentists, and factory workers, who must stand or walk for long hours at a time. It has numerous uses in sports, as in golf, tennis, and possibly some types of track work. And it is likely to be in demand by the general public, women especially, to make walking pleasanter and to relieve the strain on millions of aching American feet.

The Significance of the Helicopter

I. The Small Helicopter

Amazing Versatility Accounts for the Recent Rapid Growth of Helicopter Use in Peace and War

By L. WELCH POGUE

THE past decade has seen the development of an entirely new instrument of transportation—the helicopter. Able to take advantage of basic research already completed in aeronautical and mechanical engineering, it advanced beyond the experimental stage and became a practical vehicle only a few years after the first successful model was flown. Thereafter, its unique feature of combining the best aspects of both automobiles and airplanes saw immediate and varied commercial use.

It was not until the Korean War, however, that the sturdy faith of the pioneers in the helicopter was vindicated and the multiple uses, both actual and potential, of this versatile vehicle were appreciated. Now fully backed by an enthusiastic military, the production of, and further experimentation on, larger transport-size machines are proceeding rapidly.

The first part of this article will outline briefly the early history of the helicopter, its operational characteristics, and the many varied, and ever-increasing uses being made of the smaller helicopters. The second part will deal with the larger machines, capable of carrying seven to 20 or more persons, now a reality, and will undertake to indicate their promise in the field of commercial transportation.

Historical Development

The helicopter traces its lineage to the Sixteenth-Century notebooks of Leonardo da Vinci where there is to be found a sketch of an aircraft consisting of a lifting screw driven about a vertical axis. Intermittent experimentation occurred between that time and the Twentieth Century by a few persistent pioneers. Although deterred at first by the obstacle of inadequate power plants, and, more recently, by the diversion of capital and engineering interest to the principle of lift dependent upon forward speed, as developed in the airplane, these pioneers remained undaunted. Without their studies* the helicopter would not have developed into the practical reality it is today.[1-3]

It was only when the crude Eighteenth-Century models dependent upon muscle power or spring arrangements, and Nineteenth-Century models deriving rotor power from steam engines, were supplanted by those of the early Twentieth Century utilizing internal combustion engine power, that the problem of direct flight lift began to be conquered. According to the best information available to the writer, a Frenchman, Louis Bréguet, is generally credited with the first helicopter flight in 1907 when his machine, a helicopter weighing 1,000 pounds, and powered by four rotors, lifted itself a little way off the ground while remaining in control of the pilot.[4]

Subsequently, engineers in both Europe and America experimented with various configurations in an effort to conquer the problem of torque created by the utilization of a powered rotor. They succeeded in constructing machines which could lift themselves off the ground and fly short distances but which were plagued with instability. A few of these pioneers deserving of great credit were: Paul Cornu, Emile and Henri Berliner, Pescara, Stephan Petroczy, Theodor von Karman, D'Ascanio, Étienne Oemichen, von Baumhauer, von Asboth, and Igor Sikorsky. Recognition as a pioneer is also due to the Spanish engineer, Juan de la Cierva, who, in inventing the autogiro and in making his first successful flight in 1923, struggled with, and solved, several of the basic technological problems of rotary wing flight.†

The first successful helicopter, however, was built by Heinrich Focke, the designer of some of Germany's best military aircraft, and was flown from Bremen to Berlin in 1937. This machine weighed 2,300 pounds, had a fuselage like a conventional small airplane and blades which were supported on outriggers on either side, rotating in opposite directions to eliminate torque reaction, and was powered by a 106 horsepower engine. It achieved a flight duration of one hour and 20 minutes over a 143-mile course, an altitude of around 11,000 feet, and a maximum speed of 76 miles an hour.

Shortly thereafter, in 1939, Igor Sikorsky, who had resumed his helicopter studies commenced in Kiev in 1909, after working with fixed-wing aircraft in the meantime, produced the first successful machine in this country, utilizing the principle of the single articulated rotor with a smaller auxiliary rotor at the tail to provide torque balance.

This marked the advent of the helicopter industry in the United States.[5] Truly remarkable progress has been made since then, not only in helicopter design

* Please see numbered references at end of article, page 159.

† The chief distinction between the autogiro and the helicopter is that, in the autogiro, the movement of the rotor is caused by the aerodynamic forces set up as a result of the craft's movement through the air (through the use of a conventional propeller), while in the helicopter, power is applied directly to the rotor which determines lift as well as movement in any direction through tilting the direction of lift.

First successful helicopter to be flown in the United States was designed by Igor Sikorsky. Shown at the left is the S-51 helicopter of the Sikorsky Aircraft Division of United Aircraft Corporation.

and production,[6-9] but in the wide acceptance and utilization of the helicopter by the armed forces (greatly assisting in its development), by many other government agencies, and by private concerns for use in agriculture, industry, and commerce. Partial credit can be given to the ability to draw from technological advancements already achieved in aircraft and engine design and in metallurgy. However the helicopter would still be but a dream without the brilliant inventors and engineers who have tackled the problem, the farsighted industrialists who risked their capital in backing them, and the many individuals, both in government service and in private life, who have enthusiastically backed the helicopter and have made significant contributions to the advancement of the helicopter art.

Operational Characteristics

What is it that has caused this growth of the helicopter industry in such a short time? The answer to this question lies in the amazing versatility which the craft possesses.

It can ascend and descend vertically. This eliminates its dependence upon conventional expensive airports with their related air-traffic problems. It can hover motionless in mid-air. It can hold a speed varying from zero to maximum. It can stop quickly and hover in mid-air, and it can move sidewise and backwards. In these respects it exceeds the maneuverability of both the airplane and the automobile. With suitable universal (flotation) gear presently in use, it can land on water, ground, swamps, marshy areas, deep snow, or on ice — a boat, aircraft, and surface vehicle all rolled into one.

Still another of the gratifying characteristics of the helicopter is the fact that in the event of power failure it has an "automatic parachute" available through the principle of autorotation of the rotor. This factor, plus careful engineering design, has been responsible for a truly remarkable safety record in helicopter operations.[10, 11]

Small Helicopter Types††

During the first part of the last 10-year period, helicopter production was limited to two companies: the Sikorsky Aircraft Division of United Aircraft Corporation and the Bell Aircraft Corporation. The production of Sikorsky Aircraft was mostly for military purposes. The production of Bell was used both in military and commercial operations. As would be expected, the first machines of these companies were all small craft with cruising speeds somewhat below 100 miles per hour.

By the end of 1949 Sikorsky Aircraft had delivered approximately 700 of its helicopters. Of these, approximately 500 of the R-4, R-5, and R-6 models were delivered before the cutbacks at the end of World War II, a part of them having been manufactured by Nash-Kelvinator in Detroit under a license agreement. Sikorsky Aircraft's first postwar machine was the four-place Model S-51, which was first flown in February, 1946. In April of 1950 Sikorsky Aircraft brought out the S-52-2, a three- to four-place craft with a useful load of 1,050 pounds.

The Model 47 of the Bell Aircraft Corporation was first flown in October, 1945, and received the first commercial helicopter license to be issued by the Civil Aeronautics Administration in March, 1946. This model, subsequently developed to the 47D series, is now a three-place craft with a useful load of 989 pounds. By the end of 1949, Bell had built and sold over 300 of these small helicopters.

More recently a number of other companies have developed small helicopter models with varying configurations. Among these are Hiller Helicopters, Inc., which has in production its Model 360, a three-place craft which is now in commercial use, particularly on the West Coast. Kaman Aircraft Corporation has also developed a three-place helicopter. Some six other companies have similar models, not yet in large-

†† A discussion of the more recent large transport-type helicopters will appear in Part II of this article.

scale production. Full descriptions of all of these developments are readily available.[12-14]

General Uses of the Small Helicopter

In view of the helicopter's amazing operational characteristics, it is not difficult to realize that it has received wide acceptance by the military. This aspect of the helicopter's success will be discussed in detail below. Even more remarkable, however, in view of the fact that it was only five years ago that the first of the small helicopters was certificated for commercial operations by the Civil Aeronautics Administration, is the reception it has received in agriculture, industry, commerce, and many other fields.

There are now over 40 companies, in this country alone, specializing in helicopter operations. Quick to recognize the unique operational characteristics of the helicopter, they now stand ready to perform a variety of jobs – everything from spraying a single field to rid it of the potato bug, to engaging in extensive aerial survey work in rugged Alaskan terrain of the Northwest on behalf of the United States Geological Survey.

These enterprising new commercial operators have been tested in the crucible of competition and have come out with flying colors even though hampered with the high initial capital outlay of the helicopter itself and high operating costs normally to be expected in any newly developed machine, both obstacles of which will be minimized as quantity production and further improvements occur.

Agricultural Uses. One of the most important commercial utilizations of the small helicopter has been in crop dusting and spraying. Although presently more expensive than either surface or conventional aircraft spraying, helicopter spraying has now passed from the experimental stage to become the main business of a number of companies in farming areas in the United States and, indeed, all over the world. The helicopter, however, not only accomplishes a job faster than ground equipment but it can be used when ground equipment cannot be used, as, for example, when the ground is too wet. This is of particular importance in the case of cranberry bogs and similar fields where ground equipment would destroy portions of the crop. The helicopter, in many instances, is also superior to conventional aircraft in dusting. Its unique slow-motion quality permits precisional treatment unattainable by aircraft. It can also be used for dusting where topographical features prevent aircraft from operating, where airport refueling points are far from the fields to be dusted, or where a wind is present which would carry away aircraft spray before it has time to settle or, indeed, might carry the spray to an adjoining crop of a different type to which the spray may be harmful. The helicopter can also seek out pests before they reach damageable crops, as the farmers of Argentina will attest in view of the successful attacks on locust hordes. Some 16 small Bell helicopters have been engaged in the battle in Argentina alone, and similar experiences have been recorded in Iraq and Venezuela.

Increasingly more frequent uses in agriculture may be found for the unique downdraft created by the helicopter. Thus it has been used literally to "blow away" the drops of water which collect at the base of cherry stems after a rain and to eliminate the water absorption which may swell the fruit and can break the skin. It has also been used to force a downdraft of warmer air onto a crop threatened with frost, and to raise ground temperature – which is particularly important where smudge pots are undesirable because of nuisance to nearby residential areas. Its downdraft was recently used to harvest 1,500 acres of figs at a rate of one acre per minute.

In days to come, particularly with the decrease in the cost of the helicopter, the farmer may well find it an all-around work horse.[15-17]

The H-13D helicopter of the Bell Aircraft Corporation shown here is the Army version of the Model 47 helicopter. First flown in the fall of 1945, the Model 47 initiated commercial helicopter flying in the United States.

United States Army air-evacuation type helicopter, H-23A, manufactured by Hiller Helicopters, Inc.

Power and Pipe-line Patrol. Another important use of the helicopters has been in power and pipe-line patrol, in both private and public enterprises. Originally envisioned by Bell and three private power companies in California, the idea is now utilized by a number of companies in this country and in Canada. Contracts have been let for helicopter patrol of the 2,500-mile Bonneville Power System in the Portland-Seattle area since the summer of 1948, and to provide routine inspections over the 7,000 circuit miles of power lines which form the Tennessee Valley Authority's far-flung system since February of 1949. T.V.A. has experienced a reduction of costs by half since the helicopter can patrol some 800 miles a week, as opposed to the 40 miles per week possible for a man on foot. Furthermore, helicopter inspection affords an opportunity to see the condition of power lines not readily discernible from the ground.[18-20]

Oil Survey and Mineral Detection. The marshlands of Louisiana have long been inaccessible to geologists in their search for oil. This problem was conquered to some extent by the use of the cumbersome marsh buggy, but soon conflicted with another important Louisiana industry by destroying the muskrat runs. The helicopter was then brought in to engage in the gravity-meter survey (the equipment for which weighs only around 60 pounds), but its temporary use quickly became permanent when it was realized how much faster it could do the job and at approximately one-third of the cost. By the beginning of 1950 there were 10 helicopters engaged in full-time oil surveys in Louisiana alone.[21-23]

The helicopter is also used in mineral detection — not only from the air but as a vehicle for reaching inaccessible areas for ground surveys and eliminating the "walk in," whether in the jungles of Guatemala or in the mountains of Canada.[24]

Forest Service. The value of the helicopter to forestry has been proved under a number of dramatic circumstances. By 1948 helicopters had been utilized in five major forest fires in California alone, and a veteran of the Forest Service, United States Department of Agriculture, was able to declare that "after 25 years I have seen what I dreamed of—a service that gets me what I need there right now." A crew of men, untired by the "walk in" (usually accompanied by exhausting mountain climbing), can be brought directly to the burning area and kept supplied. The downdraft of the helicopter itself again comes into play by whipping up backfires and retarding free-burning brush fires by kicking up an adverse wind in its face.[25, 26] In addition the Forest Service has officially recognized the helicopter as the most efficient way to carry on the process, begun in 1932, of reseeding rocky, fire-denuded watersheds with mustard seed, to retard soil erosion and to assist in reforestation. At first, hand sowing was used but that required 10 days for a 12-man crew to seed 1,000 acres. Seeding from airplanes was tried next, but then areas along steep slopes, unavailable to the airplane, could not be seeded at all; seed distribution was uneven, and markers and signalmen were required on the ground to keep the pilot on his course and advise him of too light or too heavy seed discharge, or of areas that he had missed. Along came the helicopter, however, and seeded some 1,045 acres in eight and a half hours with an even distribution at a cost of about $0.025 more an acre than the airplane. These, and other advantages, have led the Forest Service to use over 2,000 hours of helicopters during the years 1948 and 1949 alone—just the beginning.

Cartography. Other agencies of the government have recognized the tremendous value of the helicopter in mapping work, in particular the United States Coast and Geodetic Survey, the United States Geological Survey, and the Army Map Service. These activities have been carried on in such widely separated places as Death Valley in California, Colorado, Cuba, Panama, and Alaska. In Alaska alone there were nine helicopters operating during the summer of 1949 and the operating cost per mile was $4.00 cheaper than

ground travel for a similar adjacent area. To the saving in dollars should be added the tremendous savings in time, since an engineer can cover several times as much area in the same amount of time without exhausting hours of climbing. In addition to its function as an aerial pack mule carrying personnel and supplies to inaccessible places, the helicopter has been used as a basic mapping instrument concerned with profiling and triangulation. It can hover directly over the position of a proposed ground station: the hovering helicopter can be utilized as the triangulation point for ground observers, and the heights of needed towers can be determined accurately by a weighted steel tape suspended from the helicopter.[27-29]

Coast Patrol and Rescue Work. One of the most vital functions which the helicopter can perform is that of coast patrol and rescue work. The Coast Guard was one of the first users of the helicopter. Recognizing the helicopter's amazing versatility has led to a stepping up of its functions as a "sea nurse"[30] and many a lost fisherman and sick mariner afloat owe their safety, and often their survival, to its use. Lighthouse supply and pilot duties in harbors are just a few of the other functions which small helicopters have, and can continue to perform.

Traffic Control. The forward-looking New York Police Department added its first helicopter, a Bell, to its force in the latter part of 1948. Soon the papers were filled with stories of helicopter rescues by the police from the East River, the Hudson, and the New Jersey marshes. In June, 1950, three of Bell's latest Model 47D's were added to the New York police force. These helicopters were soon put to multiple uses, including rescue work, and the more efficient exercise of the important function of traffic control utilizing the superior intelligence gained from a bird's-eye view of the situation in transmitting directions to those on the ground.[10, 31]

Mail Service—The Forerunner of Metropolitan Passenger and Property Service. Perhaps the most publicized commercial use of the small helicopter has been in expediting mail service in metropolitan Los Angeles and Chicago. Although these operations have and will continue to perform a great public service in their own right, one of their greatest contributions has been in developing the experience from which will spring metropolitan area passenger and property service, utilizing large transport helicopters as described more fully in Part II of this article.

It is a well-known fact that most of the time in air-mail delivery is consumed in ground time at the point of origination and destination, rather than in direct flight. If a helicopter could pick up the letter at the suburban point and carry it directly to the airport, and, at the other end, carry it directly from the airport to the suburban destination, this ground time would be substantially reduced.

Pursuant to this principle, and probably with the desire to accumulate experimental information as to a scheduled helicopter operation upon which to base conclusions as to passenger potentialities, the Civil Aeronautics Board granted Los Angeles Airways a certificate of public convenience and necessity in June of 1947 authorizing it to operate between the airport and some 29 suburban points in the Los Angeles Area, as well as between the airport and the main city post office. Utilizing five Sikorsky four-place S-51 helicopters, the company has been flying scheduled air-mail service since October of 1947 (now on both day and night schedules) with better than a 96 per cent completion factor, and up to November of 1950 had carried over 10,000,000 pounds of mail in some 100,000 flights. On May 1, 1951, the Assistant Postmaster General testified that this Los Angeles helicopter service had cost the Department three mills per piece of mail carried.[32]

Similarly, Helicopter Air Service was granted a certificate in November, 1948, to serve the Chicago Metropolitan Area and commenced service in August of 1949. Service is provided by a shuttle route between the Midway Airport and the General Post Office in

The HTK-1 helicopter of the Kaman Aircraft Corporation is convertible into an aerial ambulance and will carry pilot, attendant, and litter.

The "Little Henry" helicopter of the McDonnell Aircraft Corporation seats two passengers. This helicopter appears to be stripped of all nonessentials.

downtown Chicago (flown 18 times daily) and three circular routes serving 43 suburban communities (flown 3 times daily) which are 106, 102, and 89 miles long, respectively. Utilizing six Bell three-place Model 47D helicopters, the company achieved a completion factor of 95.48 per cent during its first year of operation and carried over 2,190,790 pounds of mail.

The use of the helicopter in expediting air-mail delivery has spread to the continent of Europe. Belgium now has such scheduled helicopter service from Brussels commenced in August, 1950, and conducted by Sabena Airlines, serving eight cities with two Bell Model 47D-1 helicopters.[33] British European Airways instituted a scheduled helicopter passenger service on June 1, 1950, between Liverpool and Cardiff utilizing three Sikorsky S-51 helicopters, and by the end of the year had attained a 96.5 per cent completion factor. It has recognized, however, that passenger service can best be provided with larger craft.[34-36]

Miscellaneous Commercial Uses. Only a beginning has been made in the discovery of uses for the small helicopter. The Game Department of the State of Washington has utilized the helicopter for determining the size of elk herds and the sufficiency of feeding areas.[37] Helicopters have been used on a number of occasions in the deadly fight with the anopheles mosquito in spraying stagnant pools to prevent malaria,[17, 38] and many civic health departments are taking increased interest in this activity, as possibly being the preventative of polio as well.[17] The value of the helicopter in the fishing industry has been touched upon when it sought out schools of tuna and whale and radioed the fishing fleet an exact location thereof,[17, 39, 40] and when it planted trout in the waters of the State of Washington.[41] The success which helicopters have had in military wire-laying points to an important peacetime use in this activity, as well as pipe laying.[42, 43] Its value in saving time in travel when important persons must be transported from building to building is apparent.[44-46] A forerunner of extensive passenger service to be discussed in detail later has been a company which started a tourist service in the Grand Canyon area on June 1, 1950, and by the end of the year had carried over 2,000 passengers and now has three Hiller 360's (Hiller Helicopters, Inc.) in use.[47] The utilization of large "flying cranes" in construction activities in isolated areas was recently pioneered when a dam was built near Vancouver, British Columbia. Some 400,000 pounds of materials, equipment, and supplies were flown in by helicopter from a loading base five miles away to a 15-foot square landing field blasted out of the rock.[48] As for the rest, all that can be said is that the helicopter has been used for everything from taking movies of game herds in the Belgian Congo,[49, 50] to making a snow survey in California to gauge the water supply,[51] to searching for Indian relics in the Canal Zone.[52] Its use by newspapers for fast and unusual coverage,[17] as a relaying station to extend the range of television transmitters, in television tower selection, and in radar calibration,[42] and as suburban delivery vehicles are other important functions.

Private Vehicles. One of the greatest potential uses of the small helicopter is as a private vehicle.[53] The biggest obstacle up until this point has been its high initial cost. It is hoped, however, that with mass production presently being stimulated through large military orders, the cost problem will be surmounted. Even now Hiller Helicopters, Inc., of Palo Alto, Calif., is prophesying with respect to its two-place, ram-jet powered *Hornet* weighing 356 pounds empty, that it should sell at a price of $4,900 as soon as defense priorities are relaxed.[54] Visions of a helicopter in a few backyards may thus not be too far from reality.

Cost Considerations

It is important to note that neither the capital nor the operating costs of helicopters should generally be compared with those of fixed-wing airplanes. A com-

(*Continued on page 156*)

Beneficiation of Ores

by Nuclear Methods

Artificially Induced Radioactivity Is Being Investigated as a Means of Mineral Separation

By ANTOINE M. GAUDIN
FRANK E. SENFTLE
WILFRED L. FREYBERGER

AMONG the techniques for concentration of minerals, now being studied, is that of utilizing some of the nuclear properties of elements found in each mineral. Production of minerals in usable form, in general, requires their concentration, and because of cost requirements the methods used are nonchemical, that is, there are no bulk chemical reactions taking place. Thus, the physical properties of density, magnetic susceptibility, and electrical conductivity guide the basic principles of many varieties of gravity, magnetic, and electrostatic separators, respectively. Flotation, a very important method of separation, has its basis in the concepts of the physics and chemistry of surfaces.

Use of the nuclear properties of elements presents an interesting prospect to the mineral engineer. In particular, radioactivity is being investigated as a possible means of mineral separation. The basic idea is simple enough: if two different minerals are radioactive to different degrees, this difference may be detected and a mechanism triggered which will separate one mineral from the other. Some minerals, notably those of uranium, are naturally radioactive; in the case of the vast majority, however, it is necessary to make the minerals artificially radioactive.

In the earliest days of ore concentration, the only method of separating the valuable pieces of ore from the gangue was hand-picking. The human pickers made the separation on the basis of color, heft, and in some cases, texture. Although this method afforded a satisfactory beneficiation of the raw ore in these very early days, modern methods of mass production and more expensive economy could not tolerate such a slow and expensive procedure. Moreover, it has become ever more important to use the finer portions of the mined ore as well as the very large pieces. For these reasons, hand-picking of ores became unsatisfactory except in a few exceptional cases. The only way to resuscitate picking methods is to mechanize them for cheaper and faster operation. While this has been done to a large extent by various types of magnetic and electrical separators, the mining engineer is always on the watch for new methods and possibilities. Separation on the basis of radioactivity might prove an attractive possibility to supplement the existing methods.

The process might best be illustrated with a description of the Lapointe picker, the first practical instrument designed to separate radioactive minerals on the basis of their radioactivity. As designed by Christian Lapointe of the Canadian Bureau of Mines for the concentration of uranium-bearing ores,[1] the device now in use at Port Hope and Port Radium, Canada, is shown in Fig. 1. The operation is as follows: A mixture of uranium-bearing mineral, the desired component, and other undesired gangue material is fed from a hopper, one piece at a time, to a belt. This train of mineral pieces is passed under a Geiger tube which measures the radioactive counting rate of each piece. The uranium-bearing minerals, being naturally radioactive, show a higher counting rate than the gangue minerals. The counting rate serves to determine whether the piece contains sufficient uranium. If the activity exceeds a predetermined lower limit, an electronic circuit is actuated which triggers a solenoid, and the piece under study at the time is knocked off the belt. The gangue material is collected at the end of the belt.

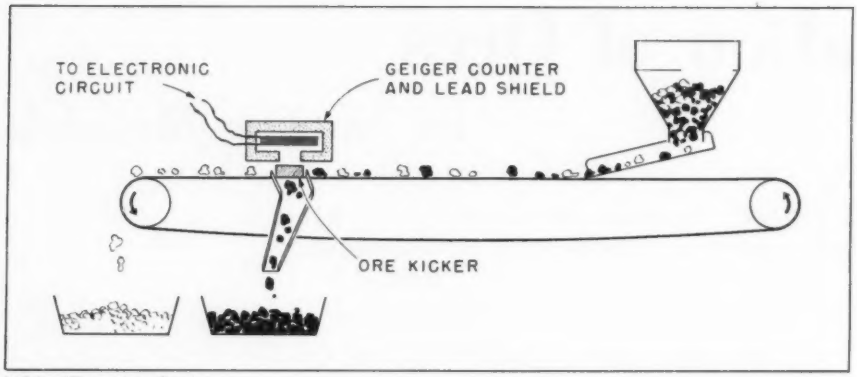
The above is a simple picture of the basic picking procedure. This idea was extended from naturally radioactive minerals to minerals made artificially radioactive by particle bombardment. The first such extension was to the concentration of beryllium-bearing minerals, particularly beryl.[2] Beryllium may be made to undergo a change in its structure if it is bombarded with x-rays of sufficient energy. Under proper conditions these x-rays will cause a neutron to be ejected from the nucleus, or core, of the beryllium atom. It is necessary that the x-rays, or gamma (γ) rays which are physically identical, have a minimum energy or threshold energy, of 1.7 million electron volts.[3] This reaction is often abbreviated (γ,n) where

[1]Kaufman, L. A., "The Radiogenic Concentration of Uranium Ores," *Transactions, Canadian Institute of Mining and Metallurgy*, LIII: 301 (1950).

[2]Gaudin, Antoine M., Dasher, John, Pannell, James H., Freyberger, Wilfred L., "Use of an Induced Nuclear Reaction for the Concentration of Beryl," *Transactions of the American Institute of Mining and Metallurgical Engineers*, 187:495 (April, 1950).

[3]To obtain an idea of the minuteness of the amount of energy represented by 1.7 million electron volts, it may suffice to state that it is the kinetic energy of a grain of sand weighing some three micrograms and moving at a speed of one centimeter per second.

On the other hand, the mass of an atom is so extremely small that if 1.7 million electron volts of energy were available for each atom, this would represent an enormous amount of energy.



M.I.T. *Illustration Service*

Schematic diagram of the Lapointe apparatus for concentrating uranium ores in which radioactive particles are automatically separated from undesired gangue by control systems sensitive to radiation. The same principles may be applied to minerals in which radioactivity is artificially induced.

γ represents the bombarding gamma ray and n the ejected neutron. What makes this transformation unique for beryllium is the value of the threshold energy. For most elements the threshold is about eight million electron volts. Beryllium has the lowest threshold of 1.7 million electron volts and deuterium, heavy hydrogen, has the next lowest, 2.2. Therefore, if beryllium minerals, together with other minerals, are irradiated with gamma or x-rays of proper energy, between 1.7 and 2.2 million electron volts, the beryllium compounds will eject neutrons and the rest of the material will remain inert. These neutrons, emitted immediately after irradiation, are counted and the procedure continues as with the Lapointe picker. This particular method is very selective, operating only for beryllium minerals, just as the Lapointe picker works only with naturally radioactive minerals.

The reverse of the (γ,n) nuclear reaction, the (n,γ) reaction,[4] is universal instead of specific. Every element is affected to a varying degree when irradiated with slow neutrons such as exist in a nuclear reactor. Depending precisely on the amount of this variation, it is possible to separate certain minerals from certain others on the basis of the radioactivity produced by neutron irradiation.[5]

It is possible to calculate the activity which a pure compound would acquire under given conditions of irradiation.[6] At a flux of the order of 10^9 $n/cm^2/$ second, these activities show a variation offering opportunity for separating minerals.

A second property of artificially radioactive elements is that each has a characteristic rate of decay, or half life. The half life is the length of time for the activity to drop to half its original value. Half lives are quite diverse, ranging from seconds to months. Thus another attribute lends itself to application in a separating process. For example, if pure minerals of fluorine and manganese were irradiated together, they both would acquire high initial activities. The fluorine, however, would decay very rapidly and for all of its activity would disappear in several minutes. The manganese activity would remain for about one day, thus making the separation possible.

Minerals met in actual practice are not pure compounds as was tacitly assumed above. In general, the impurities encountered tend to make the initial activity of all minerals higher than the calculated values. Also, variations in the amount of impurity give the activities measured for various specimens of a given mineral an appreciable spread. This affects adversely the characteristic quality of the activity exhibited by minerals irradiated and aged under controlled conditions. Consequently the possible quality of separations is blurred. However, there still remain sufficient differences to make many selections.

The application of (n,γ) induced radioactivity to practical mineral separation hinges on several factors. At present a neutron source of sufficient strength at a reasonable cost is not available. In fact, the nuclear reactor and the cyclotron are the only existing sources of neutrons capable of producing the desired activities. Then, each ore body would represent a problem in itself and would require extensive study. Also, engineering problems are present. The most serious of these, from a production standpoint, is that the picker system in its present design can work on only one piece of ore at a time, making it difficult to process a large tonnage. This difficulty of working on one piece at a time is compounded by the problem of feeding irregularly shaped pieces of ore one by one. The size of the pieces fed to the picker is also important. The smaller the pieces into which the ore is crushed, the more one mineral will be released from the other parts of the ore matrix, leading to more efficient concentration. However, the picker operates more efficiently on large pieces. Thus, some compromise must be reached. These are some of the problems presented by practical application of radioactive picking. If the process can be extended from working on one piece at a time to a volume basis, one very important objection to the picking process would be overcome. However, the basic idea of separation by induced radioactivity now exists as a possible tool for future development in the mineral industry.

[4]The (n,γ) nuclear reaction is achieved by bombarding atoms with low energy neutrons. If a neutron is absorbed by the nucleus of the atom, an (n,γ) reaction may result. In the majority of cases, the new nucleus is itself radioactive, emitting positive or negative electrons, called beta (β) rays, and gamma rays.

[5]Senftle, Frank E., and Gaudin, Antoine M., "Concentration of Ores by Induced Activities," *Nucleonics*, No. 5, **8**:53-59 (May, 1951).

[6]Senftle, Frank E., and Leavitt, William Z., "Activities Produced by Thermal Neutrons," *Nucleonics*, No. 5, **6**:54 (May, 1950).

Speech and Communication Problems

Solved by Techniques of Visible Sound and Audible Light

By FRIEDRICH VILBIG

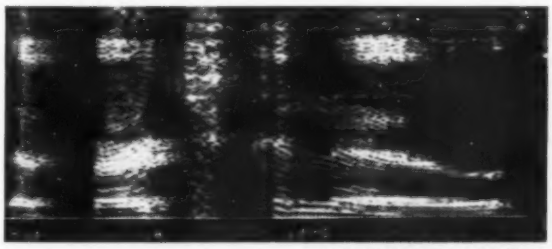
AUDIBLE sounds consist of vibrations (usually in air) having frequencies between the limits of about 20 and 20,000 cycles per second. This full range of frequencies is not necessary in speech, which can be produced intelligibly by frequencies lying within the band of from about 100 to 3,100 cycles per second. Sounds are usually complex and, instead of being composed of a single, pure tone, all frequencies between two limits may be present. Many sounds are composed of several frequency components of which the harmonics, or overtones, are integral multiples of the lowest, or fundamental, frequency. The characteristic sounds of instruments and voices are recognized by the frequencies which are present and their relative amplitudes.

In speech, the vowel sounds are produced by modulation of the air stream passing over the vocal cords, which vibrate in such a way as to produce a relatively low fundamental frequency and a variety of harmonics. The amplitudes of the various harmonics, or overtones, will each be damped in a different way for each vowel, according to the different openings of the various cavities of the mouth organ. As a result, each vowel sound may be analyzed into discrete frequency components in a line spectrum.

Sounds of the consonants, on the other hand, are produced when air enters the oral cavities without exciting the vocal cords. The frequencies present are no longer integrally related and a continuous, or noise, type of spectrum is produced, which is unique for each consonant.

By analyzing the complex sounds of speech into their frequency components and recording these on film, the so-called visible speech films, a portion of which is illustrated in Fig. 1, are obtained. The speech may be analyzed by breaking up the sound spectrum into a large number of discrete frequency channels (through the use of suitable filters) and recording the energy in each narrow channel as a function of time, in bands across the width of the film. In this way, films like that of Fig. 1 are obtained. Such films are very important for linguistic purposes to show how the line and noise spectra change with different pronunciation; they are also highly useful for the development of special communication methods, such as devices for compressing and expanding speech frequencies to fit a specified communication channel. In order that the necessary data may be extracted from the visible speech films, however, a suitable playback mechanism is required.

An apparatus that makes it possible to replay speech films is shown in schematic form in the light dotted portion of Fig. 2. The visible speech film, shown as an endless belt, is passed in front of a lamp and housing which produce a narrow slit of light across the width of the film. On the other side of the film is the light modulation disc, a light wave guide, and associated phototubes, amplifiers, and sound-converting units. Radiation from the light source penetrates the visible speech film where it is broken up into a large number of individual light beams by the band markings on the film. Having penetrated the film, the different light beams pass through a rotating modulation disc at different radial distances where they are modulated by opaque patterns on the transparent disc. The markings on the disc, one form of which is shown in Fig. 3, are such as to modify the light intensity of each beam at a rate which increases linearly with radial distance. If the modulated light beams are directed to the surface of a phototube with the aid of a light wave guide, such as is shown in Fig. 2, the phototube receives an optical signal corresponding to the original complex sound signal. The phototube converts this into an electrical signal which is amplified and made audible by the headset or a loud-speaker.



Official Photos, U.S. Air Force

Fig. 1. Section of a visible sound film portraying "the birch canoe." The vertical scale represents pitch.

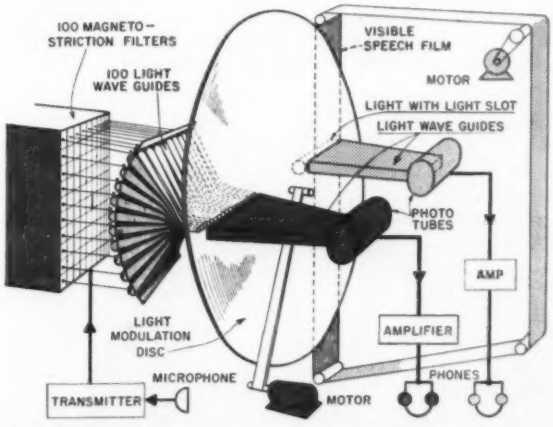
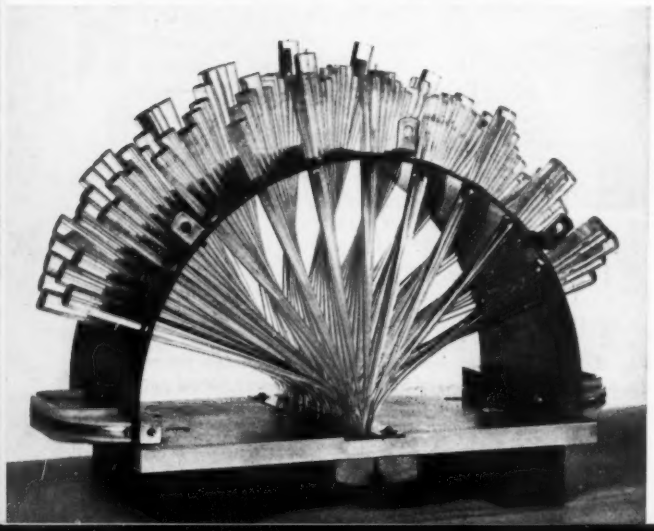


Fig. 2. Diagrammatic representation of mechanism for reproducing sound (light dotted portion). The heavy dotted portion represents apparatus for the instantaneous analysis, transmission, and synthesis of sounds.

The modulation disc supplies a wide range of frequencies (one for each light beam) and the intensity of light for each beam is determined by the markings on the visible speech film. The function of the modulation disc is to supply a wide range of frequencies throughout the speech spectrum, while the speech film alters the amplitude or intensity of the energy in each frequency channel. With correctly constructed modulation disc patterns and the proper rotational speed of disc, the variations of the light beams correspond exactly to those of the original sound recorded on the film. If the modulation disc runs at reduced speed, all the frequencies will be correspondingly diminished, and the pitch will be lowered. Conversely, the pitch will be raised, with expansion of the frequency band, if the speed of the disc is increased. The rapidity with which speech is spoken may be varied by changing the speed of travel of the visible speech film. If independent adjustments of the speed of travel of these two records are provided, the pitch, as well as the talking rate, may be modified.

The time delay required to produce the visible speech film can be a serious disadvantage when the equipment is used for communication purposes. However, by making use of the apparatus shown in the heavily dotted portion of Fig. 2, it is possible to adapt the equipment for the instantaneous transmission of speech, with or without pitch compression and expansion, but without change in the time scale or rate of talking. For this application, speech spoken into the microphone is converted into electrical wave forms by the transmitter. The electrical output of the transmitter is fed to a group of magnetostriction filters (100 in this case), each passing a band 30 cycles wide so that, for example, a channel of from 100 to 3,100 cycles per second may be analyzed. The output from each filter is connected to a small neon lamp. A certain pitch of the spoken speech passes through one filter and excites its associated neon lamp by an amount depending upon the intensity of the tone. The same is true for all other neon bulbs. With the help of the 100 light wave guides such as shown in Fig. 4, the light of the neon lamps is then concentrated to very small points along a radial line on the modulation disc. From this point on, the process of modulating the individual beams, feeding them to a phototube where they are combined, and converting the modulated light beams into sound, is the same as has already been outlined, except that speech input to the microphone can be instantaneously reconstructed. In this method, no provision is made for altering the rapidity of talking.

Fig. 4. Assembly of 100 light wave guides, of transparent plastic cones, is used to conduct the light from a group of 100 neon lamps and concentrate the visual energy into a number of 100 small points along a straight line.



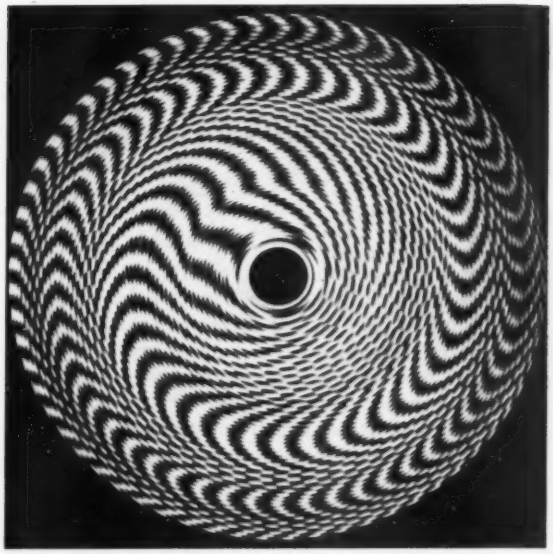


Fig. 3. One form of modulation disc, showing variations in intensity in multiwinding spiral bands.

Frequency band compression and expansion is very valuable for communication purposes. It makes possible the transmission of signals in a reduced frequency band, and enables more messages to be transmitted in a given channel. If the signal is to sound natural, the frequency compression occurring during transmission must be undone by suitable expansion in the receiving equipment. Such compression-expansion may provide a better signal-to-noise ratio than is obtainable with ordinary transmission because atmospheric noise is decreased as the frequency band is diminished. Other possibilities appear when the compressed or expanded frequency band is stored on a tape recorder and played back with increased or reduced speed. Such change in the time scale is the acoustical analogue of the optical time compression or expansion of motion pictures. Time expansion and compression also have value for linguistic purposes and for facilitating translation of recorded speech.

Although the fundamental principles have been described in terms of speech synthesis and analysis, it is possible for the method to be applied to other types of signals as well. Accordingly, the technique is applicable not only to the analysis and synthesis of music, but also to the transmission of still or moving pictures as well.

The work outlined above is the result of research conducted at the Communications Laboratory of the Air Force Cambridge Research Center. Recently the author has presented a paper, "Instantaneous Frequency Band Multiplication, Division, and Analysis" before the Acoustical Society of America, in Chicago.

THE INSTITUTE GAZETTE

PREPARED IN COLLABORATION WITH THE TECHNOLOGY NEWS SERVICE

College Choice

ADMITTED to the Institute as freshmen last September were 43 students who were the progeny of fathers who had obtained their scientific and engineering training at M.I.T. Of these 43 registrants, out of a total freshman class numbering 744 students, two have the further distinction of representing the distaff side: Miss Franceline A. Cullen of Winchester, Mass., and Miss Margaret I. Hughes of Ojai, Calif.

The Institute extends its welcome to the following 43 undergraduates—the largest representation in this group since the 1948 registration:

Student	*Parent*
Stanley H. Barriger	John W. Barriger, 3d, '21
John W. Blake	Arthur H. Blake, '19
Peter B. Brand	Arthur B. Brand, '26
Peter C. Bulkley	Reginald W. Bulkley, '27 (deceased)
Robert F. Buntschuh	Henry C. Buntschuh, '28
Laurence H. Coffin, Jr.	Laurence H. Coffin, '27
Prentiss I. Cole, Jr.	Prentiss I. Cole, '27
Franceline A. Cullen	James A. Cullen, '28
Alan S. Dana, Jr.	Alan S. Dana, '15
James F. Duffy	James F. Duffy, '11
Henry B. du Pont, 3d	Henry B. du Pont, '23
James H. Eacker	Earl H. Eacker, '22
William E. Edgerton	Harold E. Edgerton, '27
George P. Edmonds, Jr.	George P. Edmonds, '26
John M. Farmer	Edward B. Farmer, '29
Horacio A. Garcia	H. Garcia Capurro, '26
Karl O. Gelotte	Ernest N. Gelotte, '23
Edward W. Gore, Jr.	Edward W. Gore, '18
Robert W. Gray, 3d	Robert W. Gray, Jr., '29
Philip E. Gruber, Jr.	Philip E. Gruber, '25
Richard E. Hewitson	Edward H. Hewitson, '25
Margaret I. Hughes	Walter S. Hughes, '14
Glenn D. Jackson, 3d	Glenn D. Jackson, Jr., '27
Edwin A. Jeffery	Clinton A. Jeffery, '26
Erskine R. Kelly	Erskine R. Kelly, '34 (deceased)
Myles J. Kiley	Albert J. Kiley, '21
William T. Kniesner, Jr.	William T. Kniesner, '16
Arthur LaCapria, Jr.	Arthur LaCapria, '32
Richard C. Lamb	Jennings C. Lamb, '30
Barron P. Lambert, Jr.	Barron P. Lambert, '26
Charles B. Lory	Marion R. Lory, '28
Thomas A. Marlow	Arthur B. Marlow, '29
Paul G. McHugh	Gerard E. McHugh, '30
Russell G. Meyerand, Jr.	Russell G. Meyerand, '25
John C. Pease	Harold C. Pease, '29
James W. Pratt, Jr.	James W. Pratt, '23
Joseph R. Saliba	George J. Saliba, '27
Roy M. Salzman	Milton G. Salzman, '25
Kenneth L. Shaw	Kenneth R. Shaw, '26 (deceased)
Charles R. Smith	Charles C. Smith, '27
Peter H. Tolman	Mayo Tolman, '13
	Ruth D. Tolman, '11
Philip A. Untersee	Maximilian Untersee, '19
Lennard Wharton	Nathaniel P. Wharton, '24 (deceased)

Day Medal to Buerger

THE Arthur L. Day Medal of the Geological Society of America has been awarded to Martin J. Buerger, '24, Professor of Mineralogy and Crystallography in the Department of Geology at the Institute, for "distinguished application of physics and chemistry to geology."

Associated with M.I.T. since 1925, Dr. Buerger has achieved a world-wide reputation for his developments of new techniques and instruments in x-ray experimentation and for application of x-rays to the study of crystalline solids. His achievements have been recognized by his election to the presidency of the Crystallographic Society in 1939, the Society of X-Ray and Electron Diffraction in 1943, and the Mineralogical Society of America in 1947.

In reviewing his wide applications of experimental knowledge and techniques to problems in mineralogy, petrology, and geochemistry, the citation, which was made by Harry H. Hess, Professor of Geology at Princeton University, lauded the large part Dr. Buerger has played in stimulating research in the new field of crystal chemistry and crystal structure in the geological sciences.

Popular Science Lectures

SCHEDULED to speak in the 1951–1952 series of the Popular Science Lectures, presented by the M.I.T. Society of Arts on Sundays at four o'clock in the afternoon, are: Professor Arthur T. Ippen of the Department of Civil and Sanitary Engineering; Leo L. Beranek, Associate Professor of Communications Engineering; and Professor John A. Hrones, '34, of the Department of Mechanical Engineering.

On January 20, Dr. Ippen, Professor of Hydraulics, will discuss "Experimental Hydromechanics in Engineering Design." This talk will be given in the new Hydrodynamics Laboratory (Building 48).

"Sounds and You" is the title of the lecture to be delivered on February 17 by Professor Beranek in Huntington Hall (Room 10-250), M.I.T.

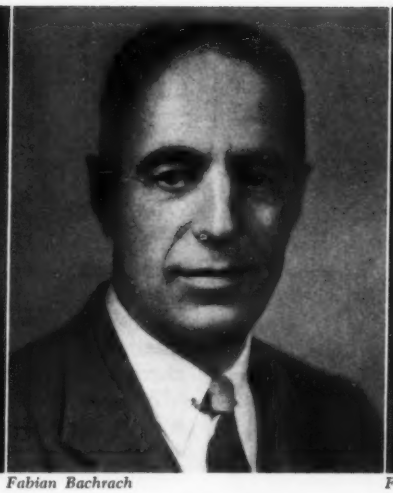
Concluding the lectures in this group, Dr. Hrones, Professor of Mechanical Engineering, will speak in Huntington Hall, on "Automatic Control in Men and Machines."

Tickets for the Popular Science Lectures may be obtained a week before each lecture by mailing an application to the Society of Arts, Room 4-415, M.I.T., Cambridge. There is no charge but the Society of Arts requests that a stamped, self-addressed envelope be sent with the application.

The opening lecture had already been delivered when copy for this issue of The Review was being prepared. On December 9, 1951, Alex Bavelas, Associate Professor of Psychology, spoke on "Communication in Human Groups."

Willard Stewart, Inc.

Walter J. Beadle, '17
Vice-president and Director of the E. I. du Pont de Nemours and Company



Fabian Bachrach

Thomas D. Cabot
Executive Vice-president and Vice-chairman of the Board, Godfrey L. Cabot, Inc.

Fabian Bachrach

Crawford H. Greenewalt, '22
President of the E. I. du Pont de Nemours and Company

New Corporation Life Members

THE election of six life members to the Corporation of M.I.T. was announced by James R. Killian, Jr., '26, President of the Institute. The six elected to life membership at a meeting of the Corporation on December 3 are: Walter J. Beadle, '17, of Wilmington, Del.; Thomas D. Cabot of Weston, Mass.; Crawford H. Greenewalt, '22, of Greenville, Del.; B. Edwin Hutchinson, '09, of Grosse Pointe, Mich.; Duncan R. Linsley, '22, of New York City; and Irving W. Wilson, '11, of Pittsburgh, Pa.

Mr. Beadle served as an alumni term member of the M.I.T. Corporation from 1943-1948. He has been with the E. I. du Pont de Nemours and Company since 1928 and on its Executive Committee since 1948.

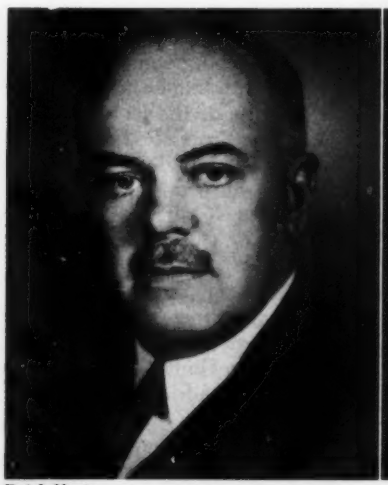
Mr. Cabot received his A.B. from Harvard University in 1919 and was a special term member of the M.I.T. Corporation from 1946-1951. He has been with Godfrey L. Cabot, Inc. since 1920, and in 1947 he became president of the United Fruit Company.

Mr. Greenewalt has been affiliated with the E. I. du Pont de Nemours and Company since his graduation from M.I.T., and its president since 1948.

Mr. Hutchinson has served as alumni term member of the M.I.T. Corporation from 1936-1941 and from 1942-1947. He has been with the Chrysler Corporation since 1924 and chairman of its Finance Committee since 1945.

Mr. Linsley was an alumni term member of the M.I.T. Corporation from 1942-1947 and regional vice-chairman of the New York Region during M.I.T.'s Development Program from 1949-1951.

Mr. Wilson served as alumni term member of the M.I.T. Corporation from 1943-1945. He has been with the Aluminum Company of America since 1911 and has been vice-president and director of a number of corporations.



Deigh-Navin

B. Edwin Hutchinson, '09
Chairman of Finance Committee of the Chrysler Corporation

Duncan R. Linsley, '22
Executive Vice-president and Director, First Boston Corporation

Irving W. Wilson, '11
Director and President of the Aluminum Company of America

The 285th Council

CONTINUING the high record of attendance which marked its October meeting, 136 members and guests attended the 285th meeting of the Alumni Council at the Campus Room of the Graduate House on November 26. As the presiding officer, Alfred T. Glassett, '20, President of the Alumni Association, handled the business portion of the meeting with dispatch.

In quick succession, minutes of the previous meeting were approved, a report that 16 members of the Council or the Faculty had visited 17 M.I.T. clubs between October 25 and November 26 was accepted; and, as cochairman of the Midwinter Meeting Committee, Royal Barry Wills, '18, presented a report on the latest progress on the program for the 1952 Midwinter Meeting of Alumni in Metropolitan Boston, which is to be held on January 31 at Walker Memorial. Henry B. Kane, '24, Director of the Alumni Fund, reported that since October 15, 3,380 Alumni have contributed a total of $57,000 to the Fund.

Attention was directed to the new M.I.T. calendar which was on display in the Campus Room foyer of the Graduate House. Orders for the calendars may be placed with the Alumni Association.

Speaking for the Administration, Karl T. Compton, chairman of the Corporation, reported that the home of the late Mrs. Forris J. Moore has been acquired by the Institute, and since October 18 has served as the official residence of E. Francis Bowditch, Dean of Students. Its location on Memorial Drive is in close proximity to both Baker and Burton House dormitories. Dr. Compton also spoke briefly on the immediate hurdles to be overcome before Universal Military Training can be put into effect.

President Glassett next introduced Dr. Dana L. Farnsworth, Medical Director at M.I.T. who first spoke about the Occupational Medical Service of the M.I.T. Medical Department. This service, now the largest single part of the Department, has grown with the need to protect the staff against radioactivity, toxic agents, and other threats to health. Dr. Farnsworth illustrated the type of function performed by this service by a few examples representative of the 480 "field trips" taken to various parts of the Institute, largely in response to staff inquiries.

Dr. Farnsworth spoke in greater detail in connection with the second of his topics, "The Faculty Health Survey." The need for such service is well known at a place like M.I.T. where the Faculty tend to overestimate their physical capacities. Acceptance of the idea is indicated by the fact that 50 per cent of the Faculty who were invited to participate in the survey have accepted. Briefly, the survey consists of a detailed questionnaire; examination by an internist, indicating the tests which seem desirable; a session with an ophthalmologist and another with an otolaryngologist; and finally a discussion with one of the staff psychiatrists in connection with Faculty attitude toward M.I.T. environment and factors at M.I.T. which tend to increase nervous tension and similar disturbances. All of this points toward the single purpose of determining ways to improve the staff environment and longevity.

Final speaker of the evening was Joseph N. Scanlon, lecturer in the Department of Economics and Social Science, who gave a highly interesting and instructive talk on his own experiences in improving relations between employers and industrial workers. The impersonal nature of many organizations and mutual ignorance or misunderstandings, on the part of labor and management, of the problems confronting the other group, were found to be the cause of most misunderstandings in industry. In those cases in which such difficulties could be overcome by developing an atmosphere of mutual trust and confidence, it was possible to increase plant efficiency and production.

With Sights Aimed

AT the meeting of the Visiting Committee on the Department of Naval Architecture and Marine Engineering,* held on May 18, 1951, Professor George C. Manning, '20, Acting Head of the Department, presented a report on the changes which have occurred and activities of the Department since the last meeting of the Visiting Committee. William S. Newell, '99, chairman, was not able to be present and Joseph W. Powell presided at the meeting. The members of the Department staff were introduced to the Committee and were invited to participate in the preliminary consideration of the Department's report.

The Committee then visited the Ship Model Towing Tank located in the basement of Building 48, the new Hydrodynamics Laboratory. The method of operating the tank and the instrumentation were explained and demonstrated. Joining the Committee for lunch were President Killian, Julius A. Stratton, '23, Provost, John W. M. Bunker, Dean of the Graduate School, and members of the Department staff. After lunch, the Committee and Dr. Killian returned to Professor Manning's office to discuss items in the latter's report, and then visited the Department facilities located in Building 5.

The Committee was of the opinion that Course XIII-C, Marine Transportation, should be continued as now organized. This will require a new instructor to replace Professor Lawrence B. Chapman, '10, when he retires on June 30, 1952. Such a person should have participated actively in the shipping industry and should have a background of engineering experience. (A meeting in New York on October 17, 1951, had started a search for a successor to Professor Chapman.)

It is believed that for the next few years the best solution of the problem of instruction in the science of marine engineering will be to continue to obtain assistance from the United States Navy by the detail of a commanding officer experienced in, and capable of, teaching this subject.

The Department's recommendation, that the acquisition of a laboratory for carrying out experimental work on ship structures is highly desirable, was approved and the Department was requested to prepare a cost estimate for desired space and equipment.

* Members of this Committee for 1950-1951 were: William S. Newell, '99, chairman, E. Wallace Sylvester, '23, John G. Pew, '26, Richard W. Berry, '32, Victor M. Cutter, Robert C. Lee, and Joseph W. Powell.

For Better Metallurgists

THE Visiting Committee on the Department of Metallurgy,* held a meeting at the Institute on April 23, 1951. Professor John Chipman, Head of the Department of Metallurgy, arranged a luncheon which was attended by most of the teaching staff and Thomas K. Sherwood,'24, Dean of Engineering. In addition to these meetings, the chairman spent some time at the Institute with Professor Chipman and certain heads of other Departments. It seemed difficult to arrange meetings when all members of the Committee could be present, but fortunately, most of the Committee members are quite familiar with Course III and are well acquainted with a number of the Department Heads.

Generally speaking, the Course appears to have been thoughtfully arranged as to subjects, the staff is made up of competent, earnest men, and the laboratories seem ample for research and the teaching of modern metallurgical practice.

The Committee recognized that in a course covering such a broad field as metallurgy, there is room for differences of opinion as to a curriculum, particularly as to the emphasis placed on certain subjects. Several members of the Committee who, since graduation, have spent many years in the practice of metallurgy, have advocated still greater emphasis on the basic sciences of chemistry (including organic chemistry) and physics, even though this might require less specialization and fewer options.

Those members present at the meetings expressed the hope that some means could be found to make greater use of some part of the long summer vacation, either in plant visits, plant employment, or in required courses of reading. The importance of the basic sciences and the advantages of summer work were recognized by the staff.

In meetings with the teaching staff, members of the Committee also stressed the importance of creating as close relations as possible with the metallurgical firms which have so generously contributed to M.I.T. It was pointed out that such contacts were most valuable to the Institute, the Faculty, and students.

Chemists Assemble

MEETING on March 4, 1951, the Visiting Committee on the Department of Chemistry† listened to a presentation of the Department's work and problems by Professor Arthur C. Cope, Head of the Chemistry Department, supplemented by Professor Leicester F. Hamilton,'14, Executive Officer, and other members of the staff. Representing the Institute's Administration, Karl T. Compton, chairman of the M.I.T. Corporation, President Killian, Professor Julius A. Stratton,'23, Provost, and Professor George R. Harrison, Dean of Science, were also in attendance.

*Members of this Committee for 1950-1951 were: William C. Potter, '97, chairman, William S. Newell, '99, Louis S. Cates, '02, Augustus B. Kinzel, '21, Carl M. Loeb, Jr., '28, Robert M. Burns, and Herbert W. Graham.

†Members of this Committee for 1950-1951 were: Bradley Dewey, '09, chairman, Robert E. Wilson, '16, Pierre F. Lavedan, '20, William M. Stratford, '21, John M. Gaines, '26, Julian W. Hill, '28, and Ralph A. Beebe.

The morning was devoted to an orientation meeting, at which Dr. Cope described the preparations that had been made. His remarks were followed by a description of the make-up of the academic staff by Professor Hamilton, and talks on the status of the Graduate School by Professor Ernest H. Huntress,'20; the graduate curriculum and research program in inorganic chemistry by Professor Walter C. Schumb; the graduate curriculum and research program in nuclear chemistry by Professor Charles D. Coryell, the graduate curriculum in physical chemistry and the research program in physical chemistry by Professors Isadore Amdur and James A. Beattie,'17; the graduate curriculum and the research program in organic chemistry by John D. Roberts and John C. Sheehan, Associate Professors of Chemistry; and the graduate curriculum and research program in analytical chemistry by David N. Hume, Associate Professor of Chemistry. Each of these talks was followed by a short informal question period.

After lunch, there were discussions on the needs of the Department, student guidance, the question of industrial contacts by the staff, and the percentage of students going into teaching as against industry, together with a discussion of plans for work in the field of organic biochemistry within the Chemistry Department. Highlighted by the statistics presented were the following points:

Two-thirds of the staff effort is devoted to undergraduate teaching. Since the Department has an average of about 35 students in each of the freshman, sophomore, junior, and senior classes, it is obvious that much of this effort is devoted to teaching chemistry as a service to other departments. After the teaching of a general Course in Chemistry to all freshmen, the major loads are in connection with the teaching of fundamental chemistry courses (analytical, physical, and organic chemistry) to chemical engineers, physicists, and other students in courses requiring these subjects.

The total of the Department's staff is 195, consisting of 30 full-time professors of various ranks, including Professors Emeriti Frederick G. Keyes and Gerhard Dietrichson (who are retired but active in research), aided by an instructor, fellows, research associates, teaching and research assistants, and clerical and other service aids.

Dr. Cope said that about half of the senior staff of the Institute had contacts with industry of one kind and another but that thesis subjects were not of an industrial nature. He felt that perhaps the greatest single need of the Department was for funds which would permit the payment of an additional $20 a month to teaching and research assistants who put in 15 hours a week. They now receive $110, in addition to their tuition at a rate of $240 for each academic term. Professor Cope felt that if this increase were possible it would serve to reduce materially the 27 per cent (data based on 1950-1951) of all applicants who are accepted for graduate study but then withdraw their names, in many cases because of larger financial help from other institutions. The Committee felt that this was an important point which, especially

(*Continued on page 152*)

BUSINESS IN MOTION

To our Colleagues in American Business . . .

The Revere Technical Advisors call upon manufacturers from coast to coast, when requested to collaborate on special problems concerning the selection, fabrication or application of copper and copper alloys, and aluminum alloys. The procedure is this: the T.A. sits down with the customer or prospect, and together they study the project put before them by circumstances. It is a close collaboration, a joint effort that frequently results in marked improvement in quality or lessening of costs, or both. Here are some examples:

• Customer staking diamond inserts in free-cutting brass rod reported that the rod was turning color under the diamond, resulting in rejects. The brass was machined with a water-soluble oil, and cleaned with a special preparation. It was discovered that parts machined with sulphur-bearing oils were being cleaned in same container. This was the cause, and the obvious remedy eliminated discolor.

• Plumbing goods manufacturer was puzzled by the fact that brass tube purchased in small grain sizes for good plating qualities was giving both bending and plating troubles. Inspection of the processes of the manufacturer showed that the tube was being annealed with a torch before expansion and plating. This annealing resulted in a large grain size of .250 mm., as shown by a typical sample sent to the Revere Laboratory. Thus the apparent anomaly was explained, and close control of annealing was established to keep grain size within the necessary limits for satisfactory plating.

• An electrical manufacturer was using a very special and expensive copper alloy as a liner for a plunger housing. He felt this extremely hard alloy was necessitated by the large amount of wear on the part. Revere suggested that Herculoy, a silicon bronze, would be worth trying in hard temper. Tests were made, and the Revere alloy was found completely satisfactory. Substitution provides a metal that is more easily available, and at the same time costs less than the original.

• A maker of a timing device was having trouble blanking cleanly a small gear part. Detail was so fine and ratio of tooth height to width so great that leaded brass had a tendency not to form full teeth. A study of this problem brought forth the suggestion that a more ductile metal was needed, namely, ¼ hard cartridge brass. This worked beautifully when tried, and customer is extremely pleased with the tremendous reduction in rejects of this difficult part.

These are just a few of a number of cases that went into the "closed" file during a single month. Almost every other supplier to industry today does much the same sort of work with his customers. He feels it is not only a fine way to build good will, but also a part of his obligation to the customers who have helped him grow. It is a fact, of course, that every dollar you pay, whether for chemicals or metals, glass, cements, papers, carries a small charge for the research and know-how and skill required to make fine products. Your suppliers have knowledge you have helped pay for — why not use it as well as their materials? The results may be as pleasing as those in the four instances just cited.

REVERE COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

Executive Offices: **230 Park Avenue, New York 17, N.Y.**

SEE "MEET THE PRESS" ON NBC TELEVISION EVERY SUNDAY

THE INSTITUTE GAZETTE

(*Continued from page 150*)

in these times of high costs, should be given consideration and emphasis.

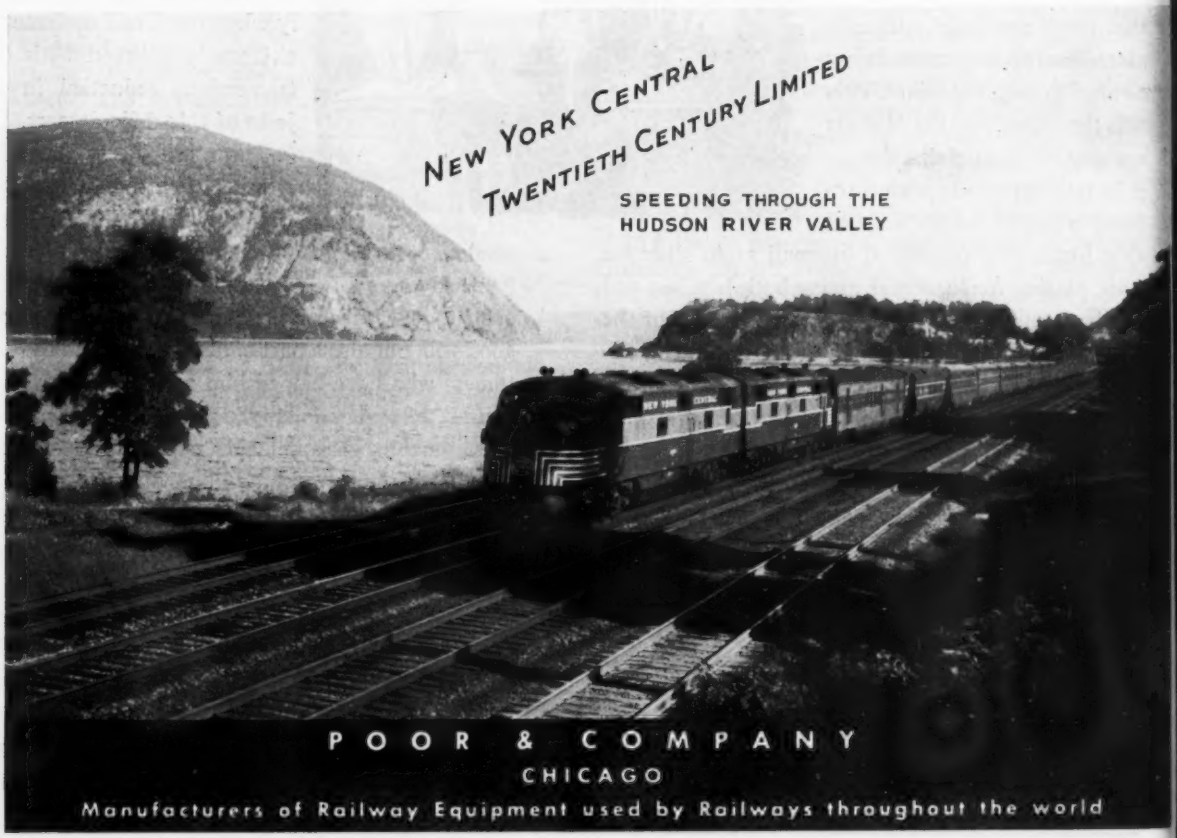
Most of the Department's graduate students are candidates for the doctor's degree, and of these, 90 per cent go into industry. Dr. Cope said that he felt the Department would be stronger if there were more space and a little more money for the appointment of post-doctoral research fellows. He believed also that if space were available, industry would probably finance many of these post-doctoral research fellowships. In presenting these points, Dr. Cope emphasized the good inspirational relationships incident to having these men working within the Department and the good public relations built up by them as they went out into positions of leadership in the profession.

There was a full discussion of the question of the desirability, in the case of the Chemistry Department, of the Institute rule that a graduate student's minor field must be outside the Department. It was pointed out that this precluded the possibility of men who are majoring for a doctor's degree in organic chemistry taking physical chemistry or analytical chemistry as their minor, and of those majoring in the latter fields taking organic chemistry or one of the other subjects as a minor. It was the feeling of the Committee that as a general rule this was probably wise, but it recommended that appropriate Institute authorities provide for exceptions to the general rule in the case of Course V graduate students who are found by the dean of the Graduate School to have studied a reasonably wide variety of subjects during their work for their undergraduate or master's degree. The Committee was of the opinion that this was necessary to insure the obtaining of scholars who insist upon such an education; that the various fields of chemistry are today fully as widely separated from each other as the fields of some departments are separated from those of others.

It was pointed out that while the Department of Biology plans to have a full professor of biochemistry there was a real need within the Chemistry Department for a specialist in the organic chemistry side of biochemistry. This was agreed to by the Administration, but the general consensus was that because of the present age distribution of the staff – 11 professors being from 55 to 65, with six to retire by June 30, 1957 – it might be best to find a young, alert biochemist who would come in on a nonpermanent tenure basis and prove his ability before promotion to one of the positions that will become available through automatic retirement. The Committee made no definite recommendations on this policy, but it was their feeling that the Department should have a good biochemist.

There was some discussion of the amount of student guidance conducted by the Department. Apparently,

(*Continued on page 154*)

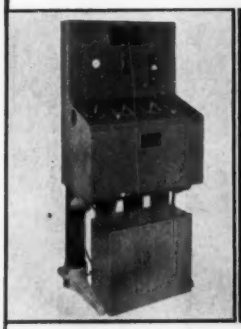


Many of the distinguished high quality products identified by these famous trade-marks are efficiently and economically produced with...
THER-MONIC
ELECTRONIC HEATING EQUIPMENT
You, too, can enjoy the same quality and satisfaction by entrusting your foundry core baking and heat treating problems to the largest producers of electronic heating equipment!
INDUCTION HEATING CORPORATION
181 WYTHE AVENUE • BROOKLYN 11, N. Y.
Induction, Dielectric and Foundry Core Baking Equipment.
KOPPERS
CORNELL-DUBILIER CAPACITORS
Remington Rand
AC
DU PONT
GT GENERAL TIME
Rheem R
GM GENERAL MOTORS
USS
CHRYSLER
STANLEY
WESTINGHOUSE
CONTINENTAL MOTORS
Ford
AC ALLIS CHALMERS
P&H
TRANE
BW BORG WARNER
Western Electric
US TIME
IBM
ACCO
UNIVERSAL
NORTON
National
Kodak
Buick
Sunbeam
DelcoRemy
GE
ALCOA
Hoover
FM
CANCO
MAXWELL MANNING & MOORE
REPUBLIC STEEL

BARNSTEAD DEMINERALIZERS PROVIDE LOW-COST PURE WATER

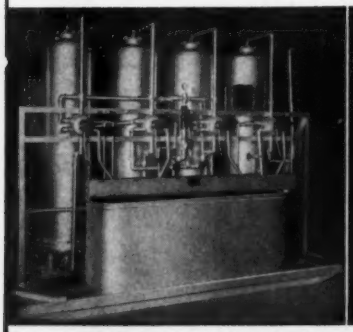
for • Electroplating • Anodizing
• Photographic Solutions
• Salt-free Rinse Water • Silvering

And Hundreds of Other Applications

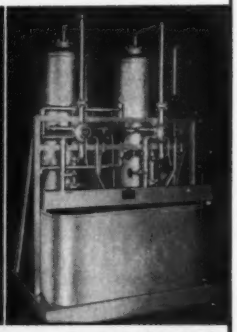


Barnstead Four-Bed Demineralizer provides pure water for hot seal tank in anodizing. 30 gal/h.

Four-bed Barnstead Demineralizer produces pure, sparkling-clear rinse water for pharmaceutical plant. 200 gal/h.



Four-bed Barnstead Demineralizer providing pure, high resistance water for electronic mfgr. 1000 gal/h.



Two-bed Barnstead Demineralizer. Used in large automotive plant. 1000 gal/h.

Selection of the best size and type of demineralizer for your operation depends on the nature of your raw water supply, flow rate needed, daily demand, and degree of purity required. Send a sample of your water to our Laboratory and Barnstead Engineers will perform the necessary analysis without obligation.

PROMPT DELIVERIES WRITE FOR FREE CATALOG

Barnstead
STILL & STERILIZER CO.
65 Lanesville Terrace, Forest Hills, Boston 31, Mass.

THE INSTITUTE GAZETTE

(*Continued from page 152*)

a minimum is carried out, and little attempt is made to discuss with students the wisdom or validity of their choice of chemistry as their life's profession. It is interesting to note that normally half of the undergraduate students take graduate work upon receiving their bachelor's degree, and that approximately 8 per cent of the present candidates for doctor's degrees are graduates of M.I.T. The Chemistry Department has, since the first doctor's degree was granted in 1908, graduated almost twice as many doctor's candidates as any other department; and of all doctor's degrees awarded, 69 per cent are in the fields covered by the Departments of Chemistry, Physics, Chemical Engineering, and Metallurgy.

The Committee was advised that the Institute's plant is being increasingly used by the Chemistry, as well as other Departments, during the summer months and was favorably impressed by the Summer School activities in modern analytical techniques, such as those using optical and electrical methods and the infrared photo-spectrometer. It was also advised that an increasing number of graduate students work all summer on their research.

There was a great deal of discussion as to whether work in analytical chemistry required the same high type of scientific ability as that in physical and organic chemistry. While one member of the Committee was inclined to look upon some of this work as a little more akin to a technology than a science, the feeling of the other members was that the solving of analytical problems in research setting is a research problem in itself. It was felt that this work should be used as a type of research to bring about an understanding of now unknown phenomena relatively insoluble by older, more classical methods of analytical chemistry. To that end, care should be taken to train in this field only topflight men of imagination, breadth of view and interest. It was felt that with proper leadership by professors of the type now working in the field, this kind of work would increase the flow of new knowledge in all fields of chemistry, and that it should be easy, in such a setting, to avoid the danger of turning out only high-grade technicians rather than true scientists.

The financial needs of the Department appear to be of a reasonably moderate nature. Professor Cope emphasized that all but approximately 12 per cent of the total budget was for fixed salary commitments. This percentage represents the total amount available for hiring teaching assistants and purchasing supplies and equipment. He pointed out that if $25,000 more a year were available for higher payments to teaching assistants, the Institute would undoubtedly be able to attract to its Chemistry Department some top-grade graduate students who now go elsewhere because of opportunities for higher pay for that portion of their time which is devoted to the very important function of teaching.

(*Concluded on page 156*)

for temperature, pressure, liquid level control . . .

Choose Klipfel valves

For dependability and economy . . . whether for plant equipment or manufactured products . . . specify Klipfel Valves . . . a wide range of standard types, as illustrated below, or controls designed specifically for you. If you have a control problem, discuss it with Klipfel Engineers. Write for the latest Klipfel Valve bulletins shown here. Each contains valuable, easy-to-use selection and specifying data. Address Dept. M-1.

#148—Reducing Valves

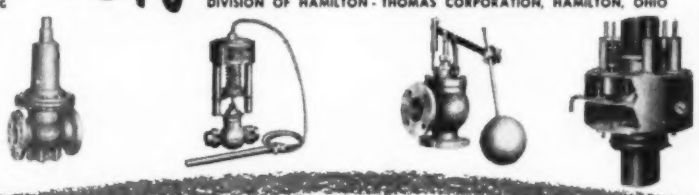
#349—Float Valves

#449—Thermostatic Valves

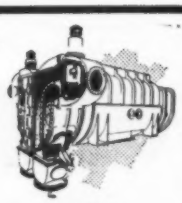
#135M—Multiport Back Pressure Valves

Klipfel VALVES INCORPORATED

DIVISION OF HAMILTON-THOMAS CORPORATION, HAMILTON, OHIO



DID YOU KNOW?

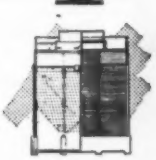


1 . . . that you can Clean Condenser Tube Sheets without Downtime or Loss of Pressure?

C. H. Wheeler Reverse Flow Condensers are "Self-Cleaning". Electrically, hydraulically or manually operated sluice gates within the condenser reverse the flow of water in the tubes to flush debris and marine growth away from tube sheets.

2 . . . that there are Vacuum Pumps with No Moving Parts . . . and often requiring No Extra Power?

C. H. Wheeler Tubejets convert waste steam into useful vacuum for pumping, refrigeration, etc.



3 . . . that a Cooling Tower can be Built to Blend with a Building—or to Stand Alone against Hurricane Winds?

C. H. Wheeler Water Cooling Towers may be sheathed with any building material to harmonize with an architectural plan. Sturdy construction is guaranteed for performance and durability.

4 . . . that Material will Grind Itself into Particles 100 Times Finer than the Human Eye Can See?

C. H. Wheeler Fluid Energy Reduction Mills reduce materials to sub-micron particle sizes. Material is conveyed by air, steam or any gas or vapor in a closed circuit at supersonic speeds causing particles to reduce themselves by repeated shattering contact with one another.

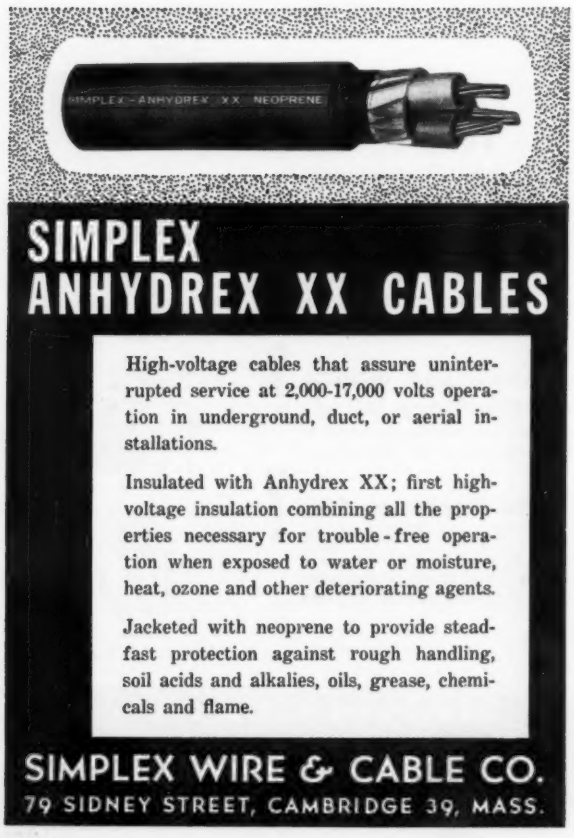
Bulletins mailed on request.

C. H. WHEELER MANUFACTURING COMPANY

19TH & LEHIGH AVENUE, PHILA. 32, PA.
DIVISION OF HAMILTON-THOMAS CORP.

Steam Condensers • Steam Jet Ejectors • Cooling Towers • Vacuum Refrigeration • High Vacuum Process Equipment • Micro-Particle Reduction Mills • Marine Condensers & Ejectors • Deck Machinery

the unusual
IS USUAL
When people need any hollow braided or solid braided cord, even if it's the most unusual, it's usual for them to turn to us. All kinds, all sizes. All purposes. Samson is the world's largest manufacturer of solid braided cotton cord.
For information and samples, write today.
A Samson PRODUCT FOR LASTING ECONOMY
Samson
CORDAGE WORKS • BOSTON 10, MASS.


SIMPLEX ANHYDREX XX CABLES
High-voltage cables that assure uninterrupted service at 2,000-17,000 volts operation in underground, duct, or aerial installations.
Insulated with Anhydrex XX; first high-voltage insulation combining all the properties necessary for trouble-free operation when exposed to water or moisture, heat, ozone and other deteriorating agents.
Jacketed with neoprene to provide steadfast protection against rough handling, soil acids and alkalies, oils, grease, chemicals and flame.
SIMPLEX WIRE & CABLE CO.
79 SIDNEY STREET, CAMBRIDGE 39, MASS.

THE INSTITUTE GAZETTE

(*Concluded from page 154*)

A.S.M. President

PROFESSOR JOHN CHIPMAN, Head of the Department of Metallurgy at the Institute, has been elected president of the American Society for Metals, the largest group of metal engineers in the world. Dr. Chipman, who came to M.I.T. as professor of metallurgy in 1937 and has been in charge of the Department since 1946, has previously served the American Society for Metals as a director (1946–1948) and as vice-president (1950–1951).

In serving as president for the more than 20,000 members of the American Society for Metals, Dr. Chipman will be head of the only engineering society devoted exclusively to the metal industry. Although the Society sponsors many professional and educational activities, it is probably best known for its publications which include the *Metals Handbook*, *Metal Progress*, *Metals Review*, and *Transactions*. It is the world's largest publisher of books for the metal industry.

At this year's National Metal Congress in Detroit, where Dr. Chipman's election was announced, the American Society for Metals sponsored both its National Metal Exposition, the largest annual industrial exposition in America, and the first World Metallurgical Congress, which was attended by more than 600 leading metal scientists from the free world. At this congress, the Society presented the first complete survey and study of the metal resources of the world.

THE SMALL HELICOPTER

(*Continued from page 142*)

parison of costs has significance only where the functions performed are comparable. Many of the services performed by the helicopter were never performed before by any vehicle. In such cases, costs should either be compared to the aggregate of costs for substitute services used before the advent of the helicopter or should be assessed against the value of the services if the function had no predecessor. In geological service work, forest-fire fighting, power-line patrol, and oil and mineral exploration, the helicopter in part replaces less efficient methods of performing inferior service. In rendering a general traffic carriage service in the lower levels of the air space above highly congested metropolitan areas, the helicopter may be said to be replacing, to some extent, services rendered by the train, street car, subway, and truck; although in a very substantial sense, it is rendering an entirely new service that will attract new business which didn't move before at all. In many of these cases it would obviously be inaccurate to compare the helicopter's operating costs, for example, to the per mile operating cost of a fixed-wing airplane which could not in any event perform the function. Furthermore, in thinking realistically about operating costs, it is necessary to keep in mind that both the original capital cost and the operating cost of helicopters will

be reduced, in accordance with the experience gained in connection with the development of all other new inventions, as further development and mass-production techniques are applied. With this in mind, it is a perfectly safe prediction today that the intrinsic value of services performed by the small helicopters (which should be the ultimate test of their economic feasibility) will shortly result in their substantially extended use in many fields of commercial activity.

Military Uses of the Small Helicopter

Lack of space prohibits an exhaustive study of the most thrilling and dramatic episode in the helicopter's development – the use of the small helicopter in the Korean War. Not only is the place of the small helicopter in all branches of the military services now firmly assured, but the experience gained in its use has pointed up the tremendous potential of the large, transport-size helicopters in military service, as will be developed later in Part II of this article.

To the Coast Guard and the Marine Corps belongs the credit of first seeing some of the most advantageous uses for the helicopter. The activities of the Coast Guard in the field have already been touched upon above. Several years ago, the Marine Corps realized that in the helicopter it had something special, and began with imagination to develop assault transport techniques and many other uses for it. Both the Marine Corps and the Navy discovered the value of the helicopter as an instrument to effect air-sea rescues from carriers. The Navy further recognized its value in speeding up the distribution of sealed-secret orders and of personnel to different ships of the fleet on maneuvers and in antisubmarine detection. For several years the Department of the Army has been moving in the direction of having each division supplied with a helicopter liaison facility. The Air Force also incorporated several small helicopters into its Air Rescue Service which saw service in lifesaving work, particularly in Alaska.

Thus, by the time of the Korean War,[58-60] all of the military services had, to varying degrees, utilized the helicopter. Within an astonishingly short period, however, as so often happens in America with a new invention, its acceptance caught on like wildfire and everybody wanted one.

The helicopters which were stationed on the larger carriers and on some of the cruisers and battleships in the Far East quickly proved their value. Pilots crashing near carriers were rescued in a matter of minutes. The value of the helicopters, as spotters for shore bombardment, greatly improved fire power accuracy. Their use in spotting and in destroying floating and fixed mines also was discovered through the Korean experience.

Both the Marine Corps and the Air Force put helicopters into Korea proper shortly after hostilities commenced. Their lifesaving performance dramatically revealed their value. By January, 1951, a very few helicopters were credited with saving nearly 3,000

(*Continued on page 158*)

B·I·W.

FLEXIBLE COAXIAL CABLES

Generally these cables conform to the dimensions and electrical properties of standard coaxial cables but are designed for unusual service conditions in aircraft and electronic applications. In addition a number of very small cables have been designed for miniature wiring.

The insulation consists of the use of teflon tape applied in a unique manner and sealed from moisture and air. The tradename for this product is "Teflex" for which patent has been received. The characteristics of the insulation are such that the cable will withstand temperatures as low as —80°F and up to 500°F for long periods of time with very little deterioration in dielectric breakdown, power factor, attenuation, change in capacity or corona forming voltage. All of these cables, although having the same type of insulation, have various types of outer coverings to be suitable for the various types of service conditions. These coverings are identified in the type number as a suffix.

The suffix "GV" refers to a teflon tape and treated fibreglass outer covering which can be rated at 400°F, the same as the insulation. The suffix "GGV" is the same except a heavy-duty braiding for improved abrasion resistance.

The suffix "RS" is a neoprene sheath compounded for flexibility; temperatures from —50°F to 250°F; flame and oil resistant.

The suffix "GL" refers to a glass braid; "NL" a nylon braid, lacquer coated, smaller in diameter which can be rated at 250°F.

TYPE NUMBER	CONDUCTOR	O.D. ±.005"	WEIGHT/M FT. Copper	WEIGHT/M FT. Total	CAP./FT. mmf.	OHMS Impedance	PRICE Per Ft.	
COX-2FS-011-GL or NL	.011" cw	.075	4	5	30	50	.13	Miniature
COX-3FS-011-GL or NL	.011" cw	.090	5	6	24	70	.16	Flexible
COX-4FS-011-GL or NL	.011" cw	.125	7	9	17	93	.21	Cables
COX-2FS-22-NL	#22 str.	.125	10	14	30	50	.16	Small
COX-2FS-22-RS	#22 str.	.170	10	25	30	50	.18	diameter
COX-2FS-22-GV	#22 str.	.135	10	18	30	50	.25	flexible
COX-2FS-22-GGV	#22 str.	.150	10	20	30	50	.28	cables
COX-3FS-22-GL or NL	#22 str.	.170	13	20	20	73	.25	Smaller than 59/U
COX-3FS-22-GGV	#22 str. cw	.195	13	30	20	73	.60	Size of 58A/U
COX-3FS-026-GV	.026"	.240	13	40	20	73	.70	RG-124/U
COX-3FS-026-RS	.026" cw	.250	13	45	20	73	.80	Equal to 59/U
COX-4FS-22-GV	#22 str.	.210	22	35	16	93	.90	Size of 62/U
COX-4FS-026-RS	.026" cw	.300	22	50	17	90	1.00	
COX-4FS-026-GV	.026" cw	.245	22	40	17	90	1.00	Size of 62/U
COX-2FS-20-RS	#20 str.	.195	14	30	28	52	.32	Equal to 58A/U
COX-2FS-20-GV	#20 str.	.165	14	25	28	52	.45	Smaller than 58A/U
COX-2FS-032-GV	.032" Ag.	.190	26	36	28	52	.52	Equal to 55/U
COX-1FS-16-GV	#16 str. Ag.	.185	22	38	46	25	.90	Special type
COX-2FS-16-GV	#16 str. Ag.	.260	30	50	30	50	1.25	Equal to 5A/U
COX-2FS-13-GV	#13 str. Ag.	.37	72	140	30	50	2.00	RG-115/U
COX-2FS-10-GV	#10 str. Ag.	.445	120	200	30	50	4.80	RG-94/U
COX-2FS-5-GV	#5 str. Ag.	.710	220	475	30	50	13.00	RG-93/U

BOSTON INSULATED WIRE AND CABLE CO. **Boston 25, Massachusetts**

Precision Electric Heat Treat Furnaces *(Laboratory and Industrial)*

Dry Type Air Cooled Transformers *(to 1000 KVA)*

Constant Current Regulators *(Static Type)*

Many nationally known laboratories and manufacturing plants use Hevi Duty Electric Heat Treating Furnaces where maximum performance is desired.

Hevi Duty specialty transformers are used extensively in the electrical control of industrial machinery and plant power distribution.

Airport and street lighting have been made safer and maintenance costs have been reduced through the use of Hevi Duty static type Constant Current Regulators.

Write for descriptive bulletins

HEVI DUTY ELECTRIC COMPANY

HEVI DUTY

HEAT TREATING FURNACES • ELECTRIC EXCLUSIVELY
DRY TYPE TRANSFORMERS—CONSTANT CURRENT REGULATORS
MILWAUKEE 1, WISCONSIN

Harold E. Koch, '22, President
Elton E. Staples, '26, Vice President

THE SMALL HELICOPTER

(*Continued from page 157*)

lives, particularly in carrying wounded men (frequently picked up behind enemy lines) directly to hospitals in situations where it is clear that they could not have survived the rough ambulance trip. Indeed, blood transfusions and other medical aid were often rendered in flight.

Other general uses of the helicopter in combat as a transportaton vehicle were soon revealed, too. It became the "Army mule" for short-range transportation of men, messages, and supplies – particularly to otherwise inaccessible areas. Its value was proved in reconnaissance, liaison work, visual-flank security,§ the posting and supply of security detachments, and the movement of security patrols from one key locality to the next. Early in World War II, the Germans used helicopters in winter maneuvers to place field artillery in mountain positions and to supply these posts with ammunition and hot food.[42]

It is no wonder, therefore, that Major General Merwin H. Silverthorn, Acting Commandant of the Marine Corps, before the House Armed Services Committee, could say: "There are no superlatives adequate to describe the general reaction to the helicopter." The boosted morale of the fighting troops caused by the helicopter was tremendous. As one pilot put it: "Every kid down there knows that no matter what happens, we will get him out if he gets hit."[55-60]

In the light of the tremendous demand in Korea for helicopters, and of the widespread publicity given to their uses, there is a popular conception that hundreds are, and have been, flying in Korea. Any such conceptions are very grossly exaggerated. Indeed, the Marines started off there with five Sikorsky S-51's and there never have been, up until just recently, but a handful of helicopters available for flying duty in the area. It is because of their great and dramatic versatility, and the fact that each one is so busy doing so much good, that it seems there must be more than was actually the case.

One hears frequent concern about the vulnerability of the helicopter in combat areas. Actually this is a misplaced fear. It would be safe to venture the guess that most assault troops would rather be landed by helicopter than by glider or parachute. Furthermore, as was pointed out by Major General Silverthorn, most of the action of the helicopter in Korea,

§ The helicopter's ability to rise vertically, suddenly, and to retire to cover, gives it a jack-in-the-box type of advantage.

TECHNICAL SALES EXECUTIVE

New England company specializing in development and sales of chemical processes and process equipment requires General Sales Manager.

Please send resume in confidence to:

President, Box A
The Technology Review
M. I. T.
Cambridge 39, Mass.

for example, has been behind ridges in rear areas where it was relatively safe from air attack. He also pointed out that if the enemy had enough aircraft to wipe out the helicopters, the ground forces might as well go home too. Indeed the relatively slow helicopter with its quick maneuverability, coupled with its capacity to go from side to side, or hover, can frustrate the attempt of a fast airplane, particularly a jet, to get its sights on the helicopter. As indicated above, the helicopter, like an individual, can easily, and does, take advantage of terrain obstructions.[42]

Although some of the potential uses of the larger helicopters in military services will be discussed in Part II of this article, it is clear that there will be an ever-increasing need by all of the military services for the smaller models. Following the tremendous acceptance of the helicopter by all the military services after the Korean experience, large orders have already been placed by the military services for smaller helicopters.

It is impossible at this time to predict as to whether more helicopters in the next 20 years will be used commercially or in the military services. This depends upon the size and activities of our armed services. The significant point is that the multiple uses for the helicopter are as great in military services as they are anywhere else. This is due to the fact that up to now and basically, it is a transportation vehicle – not a tactical fighting weapon. This points to the fact, applicable not only to the small helicopters discussed above but also to the large transport-type helicopters covered in Part II of this article, that its superior performance characteristics will make it necessary for the helicopter to be available to all branches of the military services at all levels just as jeeps, busses, trucks, and ambulances must be available at all levels. No one can have a corner on the helicopter in so far as services are concerned, because its tremendously useful operating characteristics have in a sense dedicated it to the general use.

The author wishes to acknowledge with thanks the valuable services of Brackley Shaw, and of James F. Bell in the preparation of this article. The conclusion of this article, Part II, is scheduled to appear in the February, 1952, issue of The Review.

References

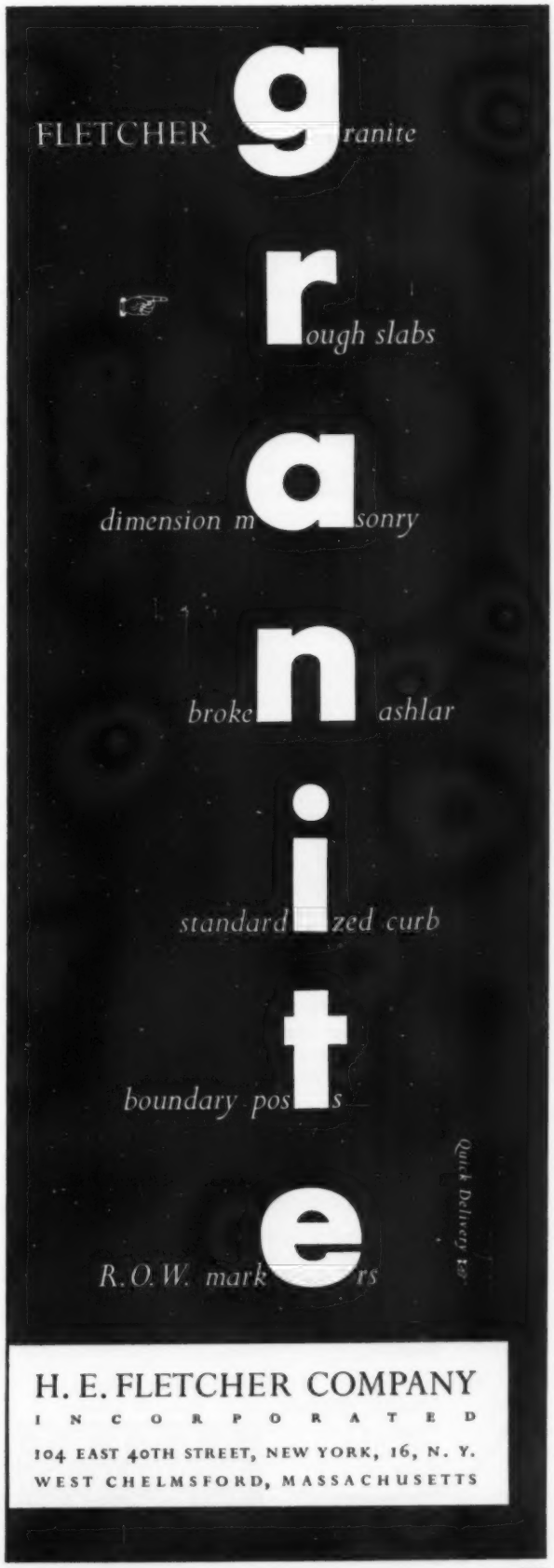
[1] Interesting surveys of the development of the helicopter are: Liptrot, Group Captain R. N., "Historical De-

(*Continued on page 160*)

GEORGE W. McCREERY CO.

Building Construction

126 NEWBURY STREET BOSTON, MASS.



H. E. FLETCHER COMPANY
INCORPORATED
104 EAST 40TH STREET, NEW YORK, 16, N. Y.
WEST CHELMSFORD, MASSACHUSETTS

Physicists, Mathematicians Electronic Engineers

Looking for opportunity? We have a new laboratory in Natick, Massachusetts, devoted to development and design of high frequency antennas. Television, mobile communications, radar, aircraft, and many other fields need more and better antennas. Your ability, complemented by ideal conditions in our laboratory, will assure your future.

You have
- ..New facilities, specifically designed for your work
- ..New England living, close to America's vacationland, and work in a small New England community near to Boston
- ..The security of permanent expansion

If you have
- ..Experience with microwave and servomechanisms
- ..A degree in physics, mathematics, or electronics
- ..Development experience in electronics, particularly antennas

WRITE TODAY TO: Personnel Manager

The Workshop Associates

Division of The Gabriel Company

Specialists in High Frequency Antennas

135 Crescent Road

Needham Heights, Massachusetts

When You Call For Any Industrial Requirement In Piping

ALBERT

"Rings the Bell"

***SPEEDLAY-PIPE SYSTEM*—completely packaged for fast-laying temporary and semi-permanent lines for water, compressed air, and other services.**

PILING—Sheet Piling—light weight Tubular—all sizes

PILE SHELLS—Spiral Welded, Hel-Cor, Riveted, CAISSONS

PILE FITTINGS—All types and sizes for steel and wood, cast steel and iron points. Plates and shoes cast steel and malleable iron sleeves.

CULVERTS—Corrugated, Spiral or Riveted Steel

VALVES AND FITTINGS—Tube turns, Dresser, Vitaulic, cast iron or steel, forged steel, special alloys, water main.

SPECIALISTS IN PRE-FABRICATED PIPING

S. G. Albert '29

ALBERT

PIPE SUPPLY CO., INC.

Berry at North 13th St.

Brooklyn 11, N. Y.

Phone EVergreen 7-8100

THE SMALL HELICOPTER

(Continued from page 159)

velopment of Helicopters," *American Helicopter,* V:12, No. 111 (February, 1947); V:12, No. IV (March, 1947).

[2] Maculey, Clinton B. F., *The Helicopters Are Coming,* Chapter III (New York: McGraw-Hill Book Company, Inc. [Whittlesey House], 1944), $2.00. The historical information contained in this article is largely based on the excellent surveys as given in this reference and No. 1 above.

[3] "Selected Helicopter Chronology," *Aero Digest,* 62:81, No. 2 (February, 1951).

[4] Liptrot, *opus cited,* V:12, No. IV.

[5] An interesting discussion of the development of the helicopter industry, manufacturing and operational, is to be found in "Up with the Helicopter," *Fortune* XLIII:91, No. 5 (May, 1951).

[6] For a discussion of some of the technical problems raised in the development of the helicopter, see "Helicopter design," *Aero Digest,* 62:76, No. 2 (February, 1951).

[7] Stepniewski, W. J., *Introduction to Helicopter Aerodynamics,* Volume I, *Performance* (Morton, Pa.: Rotocraft Publishing Company, 1950), $2.00.

[7a] Nikolsky, Alexander A., *Helicopter Analysis* (New York: John Wiley and Sons, Inc., 1951), $8.00.

[8] Piasecki, F. N., *Engineering Problems of the Helicopter* (New York: Society of Automotive Engineers, Inc., December, 1947), $.50.

[9] *Proceedings of the Seventh Annual Forum of the American Helicopter Society in Cooperation with the Institute of Aeronautical Sciences,* April 26, 27, 1951 (New York: Institute of the Aeronautical Sciences), $5.50.

[10] Interesting discussions of the fundamental principles of helicopter operations can be found in Laskowitz, I. B., "Helicopters: Their History, Development, Construction, Operation and Future," *Municipal Engineers Journal,* 35:105 (Fourth Quarterly Issue, 1949).

[11] Fay, J. S., "Some Present and Future Aspects of Helicopter Piloting," *American Helicopter,* XIII:6, No. 7 (June, 1951); XXIII:8, No. 8 (June, 1951).

[12] For the most recent compilation of the configurations of the leading small helicopters with photographs, see: *Aero Digest,* 62:54-74, No. 3 (March, 1951), and

[13] *Aviation Week,* 54:84, 85, No. 9 (February 26, 1951).

[14] For a limited discussion of the development of the small helicopter design and production in England which, perhaps because of World War II, has not proceeded at the same pace as in this country, see the interesting report of the Interdepartmental Helicopter Committee, appointed by the Minister of Civil Aviation, fully digested in *Aviation Week,* 54:21, No. 15 (April 9, 1951).

[15] An exhaustive study of the agricultural potential of the helicopter is contained in a survey entitled "Bell Utility

(Continued on page 162)

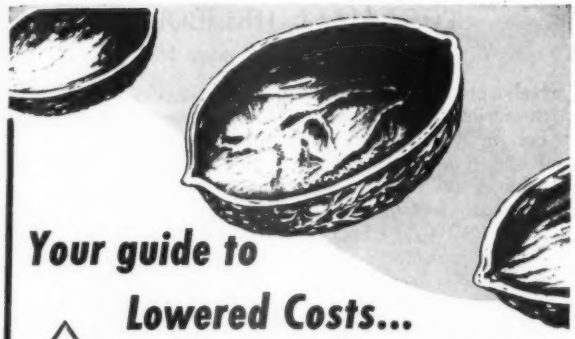
LICENSING ARRANGEMENTS WANTED

We wish to acquire patent rights on electrical components, instruments, or accessories used in the following fields:

RADIO, RADAR, OR TELEVISION, TELEPHONE, TELEGRAPH, TELETYPE, OR SOUND ON FILM, PUBLIC UTILITIES, AIRCRAFT.

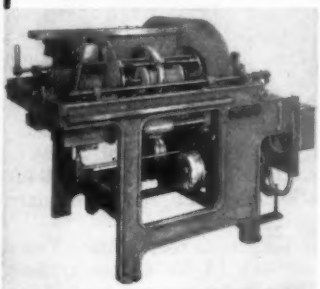
Our preference is for items that have limited rather than mass markets. We have a particular interest in switches and relays, also in telephone parts and accessories.

All replies to be held confidential. Please write to Box G Technology Review. SA-3



Your guide to Lowered Costs... in a nutshell

If you make wire, twist paper, thread or synthetic yarns, it will pay you to investigate H-D twisters, ropers, layers, bunchers, stranders. These machines, envelloping the most advanced technological improvements, are scientifically designed to (1) increase production; (2) improve quality; (3) lower manufacturing costs. Write TODAY for new bulletins and suggestions from our engineering department.



10" x 8" FORMER & TWISTER

HASKELL-DAWES MACHINE CO., INC.
2231 E. ONTARIO ST., PHILADELPHIA 34, PA.

ONLY CURTIS OFFERS ALL THESE ADVANTAGES

Availability
14 sizes — 3/8" to 4" O.D. — in stock at all times for immediate shipment. Every facility for special specification jobs.

Simplicity
Fewer parts, simpler construction, make assembly and disassembly easy. Greater strength saves weight, space, material.

Government Test
Complete equipment and personnel for testing to Government specifications in the plant before shipment insures quality.

CURTIS UNIVERSAL JOINTS

the only Universal Joint with the "Telltale" Lock Ring (patented)

Write today for free engineering data and price list

CURTIS UNIVERSAL JOINT CO., Inc.
8 Birnie Avenue • Springfield, Mass.
As near to you as your telephone

A MANUFACTURER OF UNIVERSAL JOINTS SINCE 1919

If You Need Additional Manufacturing Capacity

CALL IN

LIQUID'S

CONTRACT MANUFACTURING DIVISION

Capacity and manpower available on Machine Shop, Sheet Metal and Woodworking facilities for industrial or defense contracts.

Write for illustrated booklet "Special Contract Department" which lists and describes facilities.

Contract Manufacturing Division

THE LIQUID CARBONIC CORPORATION
3100 South Kedzie Ave. • Chicago 23, Illinois
Manufacturers of Brewing and Bottling Machinery, Soda Fountains, Gas Welding Equipment, CO_2 Gas, Dry Ice, Oxygen and Medical Gases

Rate Measuring GYROSCOPES *for*

For the accurate measurement of absolute rates of angular rotation, the Doelcam Model K Rate Measuring Gyroscope offers the following features:

1. Accuracy: 0.5%
2. Resolution: 0.1%
3. Maximum uncertainty: 0.2%
4. Hermetically sealed
5. Shock and vibration resistant
6. Microsyn pickoff: 60 — 5,000 cps
7. Thermostatically controlled damping ratio
8. Small size: 3 inches diameter x 5.82 inches
9. Lightweight: 3 5/8 lbs.

The design of the Model K Gyroscope affords wide latitude in the adjustment of parameters and permits design to any particular specifications.

Control
Stabilization
Flight Testing
Rate Computation

DOELCAM CORPORATION
56 Elmwood Street Newton 58, Massachusetts

GYROSCOPIC FLIGHT TEST AND CONTROL INSTRUMENTATION
SYNCHROS · SERVOMECHANISMS · MICROSYNS
ELECTRONIC INVERTERS

ROGERS PEET'S STANDARDS ARE RECOGNIZED AS DEPENDABLE

Making Rogers Peet Clothes ourselves in our own workrooms, we know exactly what we put into every inch and stitch of them. Our standards of Style, Materials and Workmanship are recognized everywhere as among the most unfailingly dependable in the industry.

So dependable, in fact, that for 78 years . . . ever since we began in 1874 . . . we have been able to offer "Satisfaction or Money Back" in every transaction!

Rogers Peet Company

Makers of fine clothes

In New York: Fifth Ave. *at* 41st St.
Thirteenth Street *at* Broadway
Warren Street *at* Broadway
And in Boston: Tremont St. *at* Bromfield St.

THE SMALL HELICOPTER

(Continued from page 160)

Helicopter" completed on November 26, 1947, pursuant to the agricultural Research and Development Program of the Bell Aircraft Corporation, Buffalo, New York.

[16] For typical interesting items concerning the actual value of helicopters in agricultural uses, see the following news notations in *American Helicopter*: **XVIII**:25, No. 6 (May, 1950); **XVI**:26, No. 10 (September, 1949); **XV**:22, No. 9 (August, 1949); **XIV**:4, 24, No. 6 (May, 1949); **XIV**: 6, No. 5 (April, 1949).

[17] Bell, Lawrence D., "Social Uses of the Helicopter," *Air Affairs*, July, 1948.

[18] Johnson, William G., "Air Patrol of Power Lines," *American Helicopter*, **XXI**:9, No. 3 (February, 1951).

[19] Murphy, John A., "Flying Patrolmen," *American Helicopter*, **XV**:11, No. 9 (August, 1949).

[20] *American Helicopter*, **VIII**:4, 25, No. 4 (March, 1950); **XVIII**:23, 24, No. 6 (May, 1950); **XIV**:11, 24, No. 5 (April, 1949); **XVI**:21, No. 10 (September, 1949).

[21] A detailed description of such a survey can be found in "Operation Statistics for First Oil Survey," *American Helicopter*, **XIV**:11, No. 6 (May, 1949).

[22] *Aviation Week*, **52**:101, No. 9 (February 27, 1950).

[23] *American Helicopter*, **XIV**:23, No. 5 (April, 1949).

[24] *American Helicopter*, **XIV**:23, 26, No. 5 (April, 1949); **XVIII**:21, No. 6 (May, 1950); **XVIII**:26, No. 3 (February, 1950).

[25] Jenkins, Starr, "New Technique for Fighting Forest Fires," *American Helicopter*, **XIV**:15, No. 4 (March, 1949).

[26] Jefferson, Frank J., "The Helicopter – A New Factor in Fire Control," *Fire Control Notes* (official periodical of the Forest Service, U. S. Department of Agriculture), January, 1948.

[27] See Reports of American Congress on Mapping and Surveying, June 8 through June 10, 1949, containing addresses by Colonel Fremont S. Tandy, Director of the Inter-American Geodetic Survey, and E. J. Fennell, Chief of Plans and Estimates Section of the U. S. Geological Survey, Department of Interior.

[28] *American Helicopter*, April, 1949, page 22.

[29] Gustafson, E. E., "Use of Helicopter in Surveying and Mapping," *American Helicopter*, Volume XV, No. 7 (July, 1949).

[30] *American Helicopter*, **XVIII**:3, No. 6 (May, 1950).

[31] Brennert, H. E., "New York City's Air Police," *American Helicopter*, **XVII**:17, No. 2 (January, 1950).

[32] Treasury and Post Office Departments Appropriations, 1952, Hearings before the Subcommittee of the Committee on Appropriations, United States Senate, 82d Congress, First Session, page 619 (May 1, 1951).

[33] *American Aviation*, January 8, 1951, page 36.

[34] Wigdortchik, "Some Lessons of the Liverpool-Cardiff

(Continued on page 164)

POSITION OPEN

Chief Engineer

Stainless Steel Tube Operation

New and expanding small company with excellent prospects.

Direct full data to

DAMASCUS TUBE COMPANY

Greenville, Pennsylvania

Glenn G. Geiger and family, New York

I found unparalleled opportunities

While I was still an undergraduate at the University of North Dakota, I made up my mind that I wanted to live and work in the New York area. But I was interested only in a position that would provide an adequate living, and of equal importance, one in which I would have personal contact with people and be of help to them with their problems.

So I began an intensive study of career possibilities. I found that the *one* field that offered exactly what I was looking for was life insurance. And after comparing various companies, I chose New England Mutual – the first mutual life insurance company chartered in America.

I've received wonderful training in New England Mutual. And I've found unparalleled opportunities to serve my fellow man and to give my family security.

I'm living and working in the city of my choice. I'm guiding the financial affairs of a wide variety of people, and I'm establishing many valued friendships.

No wonder I feel so strongly that life insurance offers immediate and satisfactory rewards for college graduates who work hard, have high ideals and a genuine interest in the welfare of other people!

Glenn G. Geiger

If *you* would like more information about a career in which your individual ability and industry—and nothing else—determine your income, write Mr. H. C. Chaney, Director of Agencies, 501 Boylston St., Boston 17, Mass.

• • •

One reason New England Mutual agents do so well is that they have a truly fine product to sell. The New England Mutual life insurance policy is a liberal and flexible contract that can give you *just* the kind of financial help you require.

And you will be pleasantly surprised to find that the rates for many New England Mutual policies are *lower today* than they were 20 years ago!

If you are interested in having your life insurance program custom-tailored to fit your personal or business needs, get in touch with one of your own alumni listed below, or one of the other 700 college-trained men who represent New England Mutual from Maine to Hawaii.

These MASSACHUSETTS INSTITUTE OF TECHNOLOGY men are New England Mutual representatives:

Raymond P. Miller, CLU, '18, Salem
Blaylock Atherton, '24, Nashua

New England Mutual would like to add several qualified Massachusetts Institute of Technology men to its sales organization which is located in the principal cities from coast to coast. If you are interested, write to Mr. Chaney as directed above.

The New England Mutual *Life Insurance Company of Boston*

CAN YOU BEAT THIS?

A steak dinner will be served to more than 500 at the Alumni Association's Mid-Winter Meeting on Thursday, January 31. Total cost:

$1.50 ***per person.***

We are proud of serving M.I.T. alumni and friends in this fashion. We are also proud of our annual service of 1,000,000 meals to staff and students this past year. We hope M.I.T. alumni are as proud of this record, made possible by their gift of the Walker Memorial Building in 1917.

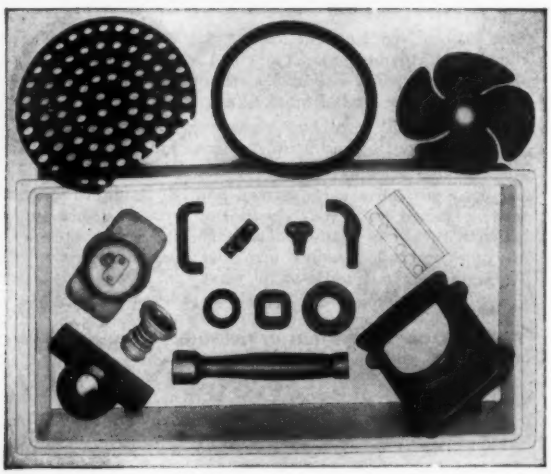
Walker Memorial Dining Service

M. I. T.

Cambridge 39, Massachusetts

A. W. BRIDGES, MANAGER

RUBBER DOES IT!



Only rubber does that job so vitally necessary in countless applications — resists the damaging action of oils, gases, fluids, greases, continuous flexing, abrasion, extreme high and low temperatures, and many other problem conditions. Throughout industry, Acushnet precision-molded rubber parts and products of natural and synthetic rubber are performing their jobs with the greatest efficiency and economy. We'll gladly suggest remedies for your troublesome applications.

Acushnet
PROCESS COMPANY
NEW BEDFORD, MASS., U. S. A.

Address All Correspondence to 774 Belleville Ave., New Bedford, Mass.

THE SMALL HELICOPTER

(Continued from page 162)

Helicopter Passenger Service," *American Helicopter*, **XXII**:11, No. 6 (May, 1951); **XXIII**:12, No. 7 (April, 1951); **XXIII**:14, No. 8 (July, 1951).

[35] *American Aviation*, **14**:35, No. 27 (January 22, 1951).

[36] "Report on Civil Helicopter Developments in the United Kingdom," prepared by L. W. McHenry, Office of the Civil Air Attaché in the American Embassy in London, June 9, 1950.

[37] *American Helicopter*, **XVIII**:9, 26, No. 4 (February, 1950); **XIV**:4, No. 6 (May, 1949).

[38] *American Helicopter*, **XIV**:24, No. 6 (May, 1949).

[39] Berry, M., "Hiller 360 Goes Whaling," *American Helicopter*, **XXIII**:6, No. 8 (July, 1951).

[40] *American Helicopter*, **XVI**:3, No. 10 (September, 1949).

[41] *American Helicopter*, **XVI**:3, No. 10 September, 1949); **XX**:17, No. 12 (November, 1950).

[42] Piasecki, F. A., "Military Aspects of the Transport Helicopter," presented before the joint meeting of the Ottawa Aeronautical Society, The Institute of the Aeronautical Sciences, and the Engineering Institute of Canada, October 30, 1950.

[43] *American Helicopter*, **XXIII**:21, No. 7 (June, 1951).

[44] The officials of the Port of New York Authority have found that the use of a helicopter (which it owns) has saved a tremendous amount of time on its inspection trips. — New York *Herald Tribune*, May 31, 1951.

[45] W. E. Reynolds, Public Buildings Administrator, testified before the Senate Public Works Sub-Committee that the use of helicopters to transport key federal officials and couriers from one dispersal point to another around Washington was presently being foreseen. — Washington *Daily News*, page 3, December 14, 1950.

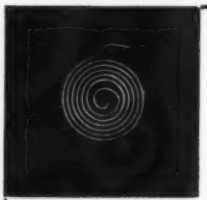
[46] The helicopter has also received use by political campaigners, see *American Helicopter*, **XVIII**:4, No. 4 (March, 1950).

(Concluded on page 166)

J. C. CORRIGAN CO., INC.
Conveyers

Distributors for
Engineers · Manufacturers · Erectors
Coal Handling Systems
Materials Handling Equipment
Portable Conveyers
Jeffrey Manufacturing Co.
Jeffrey Parts Carried in Boston Stock

41 Norwood Street, Boston 22, Mass.
Tel. GEneva 6-0800



PRECISION-GAUGED HAIRSPRINGS AND FINE ROLLED WIRE

PRECISION PRODUCTS COMPANY

WALTHAM, MASSACHUSETTS
ROBERT I. BRADLEY, '20

SCULLY SIGNAL COMPANY

VENTALARM®

Tank Fill Signal

SAFER FILLING — NO SPILLING

"FILL TIL' THE WHISTLE STOPS"

F. P. Scully '15 UNiversity 4-2900

88 First Street, Cambridge 41, Mass.

William H. Coburn, '11 William F. Dean, '17

William H. Coburn & Co.

INVESTMENT COUNSEL

68 Devonshire St. Boston, Mass.

Lord Electric Company

INCORPORATED

FOUNDED BY F. W. LORD, M.I.T. '93

1895 ELECTRICAL CONSTRUCTION 1952

131 Clarendon Street
Boston 16, Massachusetts
Telephone COmmonwealth 6-0456

10 Rockefeller Plaza
New York 20, N. Y.
Telephone CIrcle 6-8000

1201 Plaza Building
Pittsburgh 19, Pa.
Telephone COURT 1920

HAROLD J. RYAN, INC.

Air Conditioning

101 PARK AVENUE NEW YORK 17, N. Y.

The TREDENNICK-BILLINGS CO.

Construction Managers *Building Construction*

K. W. RICHARDS '07 H. D. BILLINGS '10 C. C. JONES '12 F. J. CONTI '34

10 HIGH STREET BOSTON, MASSACHUSETTS

SYSKA & HENNESSY, INC.
Engineers

DESIGN · CONSULTATION · REPORTS
POWER PLANT · WASTE DISPOSAL · WATER SYSTEMS
New York City

HOLMES & NARVER, INC.

ENGINEERS

DESIGN—CONSTRUCTION—MANAGEMENT

JAMES T. HOLMES
M.I.T. '14

D. LEE NARVER
STANFORD '14

824 S. Figueroa St. Los Angeles 17, Cal.
TRinity 8201

N. A. LOUGEE & COMPANY
ENGINEERS AND CONSULTANTS

Reports—Appraisals—Depreciation Studies
Rate Cases—Business and Economic Studies

120 BROADWAY NEW YORK 5, N.Y.

N. A. LOUGEE '11 L. A. MATTHEWS '13
J. W. McDONALD, Jr. '20 B. F. THOMAS, Jr. '13
E. S. WEST '40

CHARLES N. DEBES
AND ASSOCIATES
Engineers and Consultants

Plans, Specifications, Construction Supervision
Industrial Plant and Commercial Projects
Electrical — Mechanical — Sanitary — Structural

ROCKFORD TRUST BLDG. ROCKFORD, ILL.
C. N. DEBES '35

THE SMALL HELICOPTER

(Concluded from page 164)

[47] *American Aviation Daily*, **72**:4, No. 1 (January 2, 1951).

[48] Ager, Carl C., "Dam Construction at an Isolated Location," *American Helicopter*, **XIX**:11, No. 8 (July, 1950).

[49] *American Helicopter*, **XV**:25, No. 9 (August, 1949).

[50] The helicopter is also being increasingly utilized by movie studios. See *American Helicopter*, **XIX**:23, No. 8 (July, 1950).

[51] *American Helicopter*, **XIV**:24, No. 5 (March, 1949); **XVIII**:4, No. 4 (March, 1950).

[52] *American Helicopter*, **XIV**:24, No. 6 (May, 1949).

[53] For a discussion of some legal problems raised by the increasing use of the helicopter, see Pogue, L. W., "Helicopters and the Changes which They Require in Aviation Law," *Journal of Air Law and Commerce*, **14**:300, No. 3 (Summer, 1947).

[54] Perreault, W. D., "Hiller Hornet — Low Cost Backyard 'Copter," *American Aviation*, **14**:23, No. 33 (March 5, 1951).

[55] For a full discussion of the use of the helicopter in Korea up to date, see, Worden, W. L., "The War's Craziest Contraption," *Saturday Evening Post*, **223**:26, No. 25 (December 16, 1950).

[56] Winchester, J. H., "Helicopters at War." *Aviation Age*, **15**:20, No. 1 (January, 1951).

[57] "Mercy Is His Business," *Bee-Hive* [United Aircraft Corporation], **XXVI**:10, No. 1 (January, 1951).

[58] *The Sikorsky News*, **3**:1, No. 5 (February 9, 1951; **3**:1, No. 8 (May 11, 1951).

[59] Mashman, Joseph, "Marine Helicopters in Korea," *American Helicopter*, **XXII**:8, No. 6 (May, 1951).

[60] It is also interesting to note that the helicopter is seeing service in Malay in Britain's guerrilla warfare against the Communists. This helicopter is the Sikorsky S-51 built in England under a license agreement with Westland Aircraft, Ltd. Westland had produced over 40 of these craft by the end of 1950, most of which are flown by the Royal Air Force, although some have been utilized in Africa in spraying operations. *American Helicopter*, **3**:1, No. 3 (December 15, 1950).

LEONARD CONSTRUCTION COMPANY

Engineers and Contractors
SINCE 1905

IN THE AMERICAS AND FAR EAST

37 South Wabash Ave.
Chicago

PREPARATORY SCHOOLS FOR BOYS

CHAUNCY HALL SCHOOL

Founded 1828. The School that specializes in the preparation of students for the Massachusetts Institute of Technology.

Ray D. Farnsworth, *Principal* 533 Boylston Street, *Boston, Mass.*

HUNTINGTON SCHOOL FOR BOYS

Grades Eight to Twelve.
Thorough preparation of entrance to M.I.T.
Regular and Summer courses.
Excellent facilities for athletic & other activities.
William G. Wilkinson, Headmaster
320 Huntington Ave., Boston Tel. Kenmore 6-1800

PROFESSIONAL CARDS

JACKSON & MORELAND
Engineers and Consultants

Design and Supervision of Construction
Reports — Examinations — Appraisals
Machine design — Technical Publications

BOSTON NEW YORK

JOHN W. NICKERSON '09
MANAGEMENT ENGINEER

Advice on
LABOR RELATIONS — WAGE INCENTIVES
JOB EVALUATION — MERIT RATING

46 Mt. View Dr., W. Hartford, Ct. Tel. 32-6665
Niantic, Ct. Tel. 9-5933

EADIE, FREUND AND CAMPBELL
CONSULTING ENGINEERS

500 FIFTH AVENUE NEW YORK 36, N. Y.

Mechanical — Electrical — Sanitary
Air Conditioning — Power — Process Layouts

J. K. Campbell, M.I.T. '11

STARKWEATHER ENGINEERING CO.
INCORPORATED

Engineers and Contractors for Pumping Plants
Boiler and Power Plants, Cooling Water
and Heat Recovery Systems

246 Walnut Street, Newtonville BI 4-8042
J. B. Starkweather, B.S. M.I.T. '21

THE KULJIAN CORPORATION
1200 North Broad St., Philadelphia 21, Pa.
CONSULTANTS—ENGINEERS—CONSTRUCTORS

Specialists in
UTILITY, INDUSTRIAL, AND CHEMICAL FIELDS
Offices in
Washington, D.C.—Mexico City, Mexico,—Rome, Italy
Calcutta, India—Caracas, Venezuela

H. A. KULJIAN, '19 A. H. KULJIAN, '48

FABRIC RESEARCH LABORATORIES
Incorporated

Research, Development and Consultation
for Textile and Allied Industries

665 Boylston Street Boston, Mass.
W. J. HAMBURGER, '21 K. R. FOX, '40 E. R. KASWELL, '39

GILBERT ASSOCIATES, INC.
ENGINEERS AND CONSULTANTS

Malcolm G. Davis '25, *Vice President* Allen W. Reid '12 E. C. Edgar '35

Steam, Hydro, Diesel Power Plants; Industrial Structures; Plant Safety, Labor Relations, Utility Rates, Valuations, Reports; Large Scale Purchasing; Industrial Laboratory

New York, N. Y. Reading, Pa. Washington, D. C.
Philadelphia, Pa. Houston, Tex.

FAY, SPOFFORD & THORNDIKE
Engineers

Airports — Bridges — Water Supply and Sewerage
Port and Terminal Works — Fire Prevention

INVESTIGATIONS DESIGNS
SUPERVISION OF CONSTRUCTION

Boston New York

CLEVERDON, VARNEY & PIKE
Consulting Engineers

HERBERT S. CLEVERDON '10 WALDO F. PIKE '15
LAWRENCE J. TRACY '23

Structural Designs Foundations
Heating Ventilating and Plumbing Designs
Industrial Buildings, Reports, Investigations

120 TREMONT STREET BOSTON 8, MASS.

MAURICE A. REIDY
Consulting Engineer

BRIDGES BUILDINGS
STRUCTURAL DESIGNS FOUNDATIONS
CONSTRUCTION CONSULTANT AND ARCHITECTURAL ENGINEER

Estimates and Appraisals

101 TREMONT STREET BOSTON, MASS.

SERVO CORPORATION OF AMERICA
Henry Blackstone '37, President

Consultants on
Electronic Control Problems
for Industry

New Hyde Park Long Island, N.Y.

MORAN, PROCTOR, FREEMAN & MUESER
CONSULTING ENGINEERS

Foundations for Buildings, Bridges and Dams;
Tunnels, Bulkheads, Marine Structures, Soil Studies and Tests; Reports, Design and Supervision

Pardo, Proctor, Freeman & Mueser
Ingenieros Consultores
Ap. Correos 614, Caracas, Venezuela
WILLIAM H. MUESER '22

PRAEGER—MAGUIRE

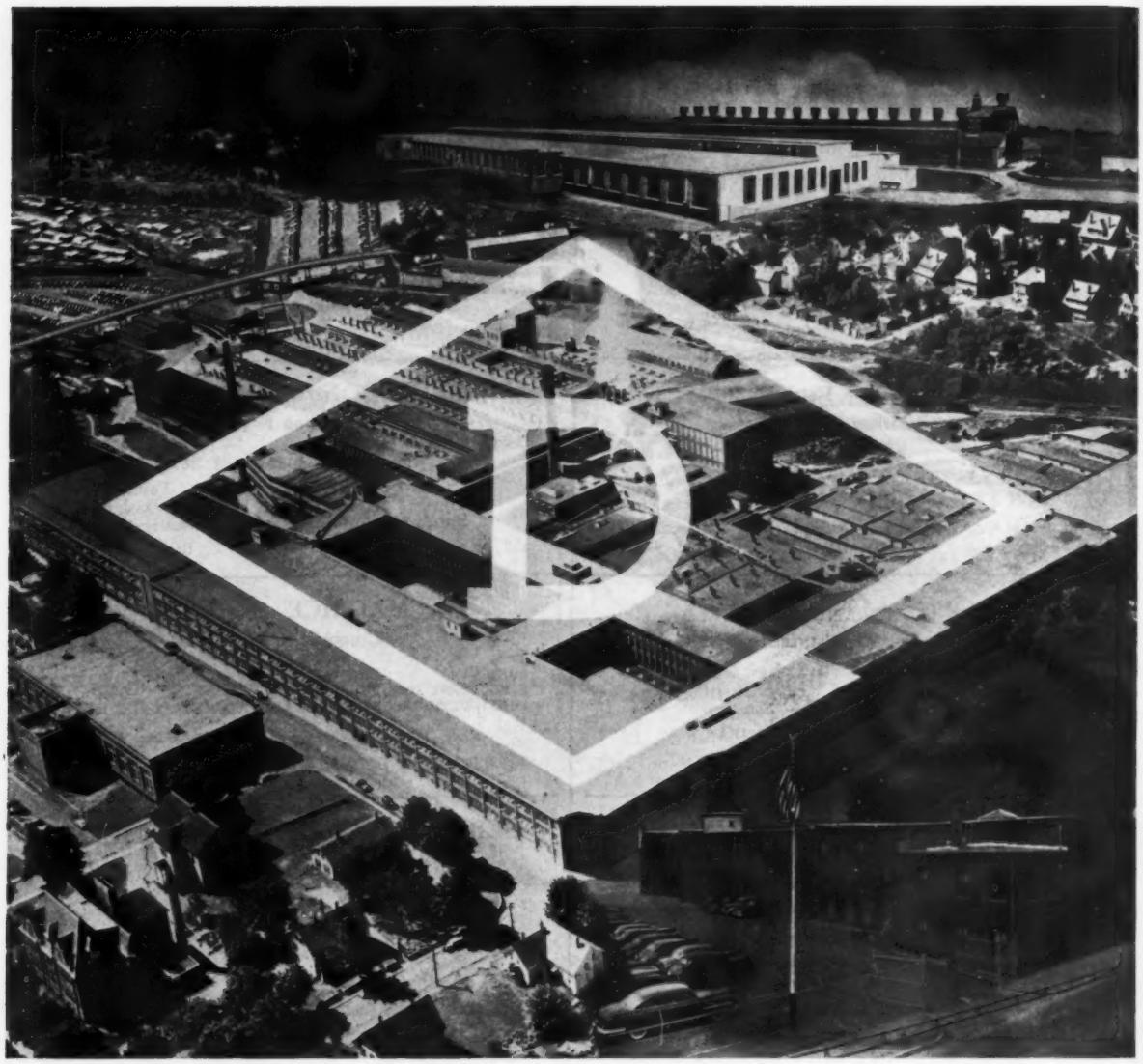
ENGINEERS

BOSTON PROVIDENCE NEW YORK

Braintree 2-2933 Hingham 6-2360

FRANK MASSA
Electro-Acoustic Consultant

99 Cedar Street
Braintree, Massachusetts
5 Fottler Road
Hingham, Massachusetts



Behind the Diamond "D" . . .

Three completely modern plants stand behind the "Diamond D" — trade-mark of Draper Corporation, the world's largest manufacturer of automatic looms.

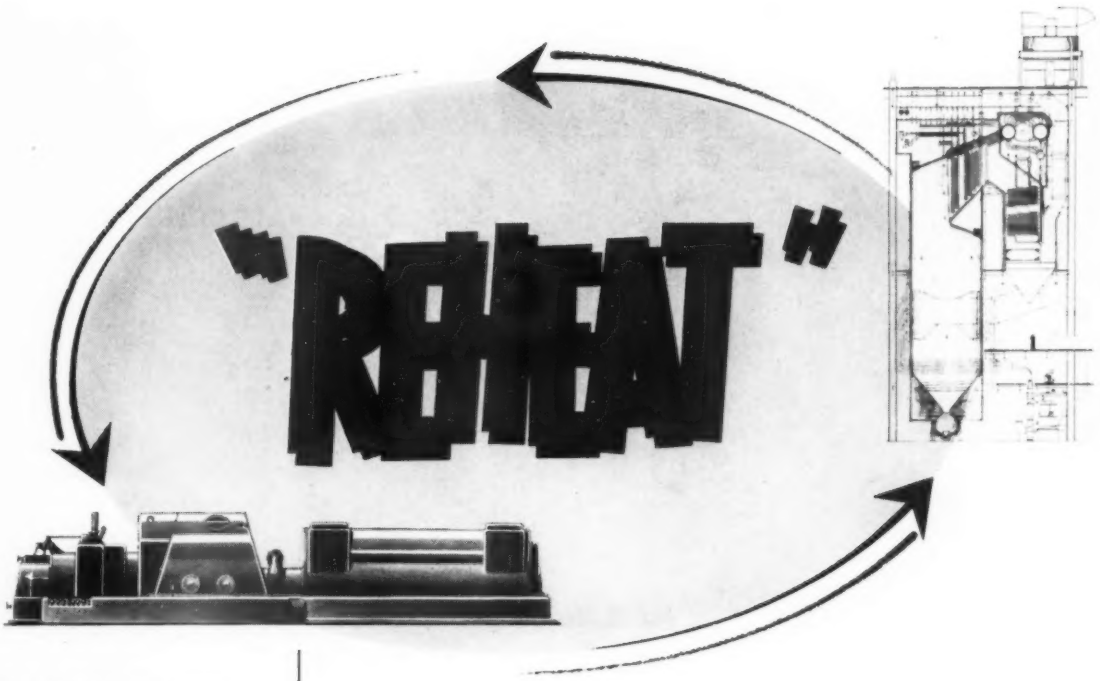
The main plant in Hopedale is one of the largest manufacturing plants in New England. The plant at Spartanburg, S.C. (upper right) manufactures repair parts and some mechanisms for Draper looms, and the plant at Pawtucket, R.I. (lower right) produces drop wires and warp stop motions.

These three plants produce the world-famous Draper loom and its accessories with the most modern and efficient foundry installations and machine tools available today.

Draper Looms Produce More Cloth at Less Cost Throughout the World.

DRAPER CORPORATION

ATLANTA, GA. HOPEDALE, MASS. SPARTANBURG, S. C.



Utilities that have purchased C-E Reheat Boilers in the past five years

	NUMBER OF BOILERS
Alabama Power Company	2
Boston Edison Co.	2
Carolina Power & Light Co.	2
Central Hudson Gas & Elec. Co.	1
Central Illinois Public Serv. Co.	2
Cincinnati Gas & Electric Co.	2
Cleveland Electric Illum. Co.	3
Connecticut Light & Power Co.	1
Dayton Power & Light Co.	4
Delaware Power & Light Co.	1
Duke Power Co.	6
Electric Energy Inc.	4
Florida Power & Light Co.	2
Illinois Power Co.	2
Kansas City Power & Light Co.	1
Long Island Lighting Co.	2
Metropolitan Edison Co.	3
N. Y. State Electric & Gas Co.	2
Niagara Mohawk Power Corp.	5
Pacific Gas & Electric Co.	2
Philadelphia Electric Co.	1
Public Service Elec. & Gas Co.	3
Rochester Gas & Elec. Co.	2
Rockland Light & Power Co.	1
South Carolina Elec. & Gas Co.	2
Southern California Edison Co.	2
Tennessee Valley Authority	4
Union Electric Co.	2
Virginia Electric & Power Co.	2
Wisconsin Electric Power Co.	5

...another reason why electricity will continue to be AMERICA'S BIGGEST BARGAIN!

By now nearly everybody knows that electricity is about the only important commodity that still costs less than it did prewar. But probably few people outside the power field know the reason for this amazing fact.

It is that America's electric utility industry has a long established policy of giving every possible encouragement to technological progress, and has been quick to invest its capital in any development that promised higher operating efficiency. Thus the utilities have been able to meet vastly increased fuel, operating and tax costs, and still sell kilowatt-hours at an average rate below that charged during the thirties.

A case in point is "Reheat" — the major post-war trend in power station practice. Reheat is the word used to describe a steam cycle whereby steam, after having passed part way through the turbine, is returned to the boiler for reheating to its original temperature. With energy restored, it completes its work in the turbine with a marked gain in efficiency.

Combustion Engineering — Superheater, Inc. has played a leading role in developing the modern reheat boiler. Evidence of this is the accompanying list of forward-looking utilities throughout the country which have selected C-E Reheat Boilers for their current expansion programs.

The kind of design leadership which C-E has brought to the development of reheat boilers is indicative of what you can expect when you come to Combustion for your steam requirements . . . whether utility or industrial . . . whether power or process . . . whether large or small. B-500

ALL TYPES OF STEAM GENERATING, FUEL BURNING AND RELATED EQUIPMENT

COMBUSTION ENGINEERING — SUPERHEATER, INC.

Combustion Engineering Building • 200 Madison Avenue, New York 16, N. Y.

Type 1803-A

A-C Vacuum-Tube Voltmeter

Moderately Priced at **$155.00**

Moderately Priced

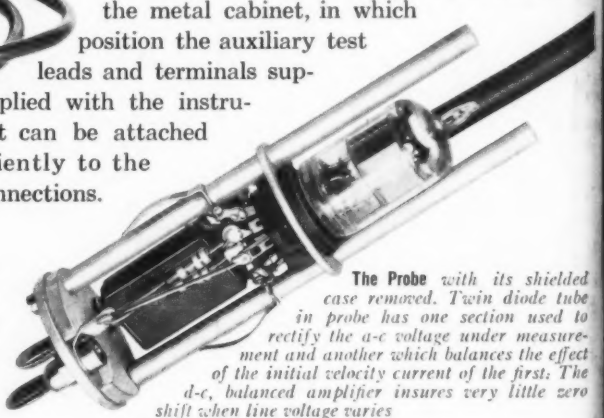
A-C Vacuum-Tube Voltmeter

with Many Operating Conveniences

The Type 1803-A Vacuum-Tube Voltmeter duplicates the performance of its pre-war predecessor, the popular Type 726-A instrument, at a price less than the latter and with many improvements including a smaller and completely shielded probe, a single zero adjustment for all ranges, a power supply not limited to a single frequency, and smaller and lighter construction.

This voltmeter is a peak-reading instrument with a straightforward circuit. It consists of a diode rectifier mounted in the probe, followed by a d-c amplifier and an indicating meter. The d-c amplifier uses a twin triode in a degenerative, balanced circuit.

The probe plugs into supports on the side of the metal cabinet, in which position the auxiliary test leads and terminals supplied with the instrument can be attached conveniently to the input connections.



The Probe *with its shielded case removed. Twin diode tube in probe has one section used to rectify the a-c voltage under measurement and another which balances the effect of the initial velocity current of the first. The d-c, balanced amplifier insures very little zero shift when line voltage varies*

Five Ranges Four scales cover the ranges from 0.1 to 150 volts a-c (full scale: 1.5, 5, 15, 50 and 150 volts)

Good Accuracy ±3% of full scale on all ranges for sinusoidal voltages, subject to frequency correction above 50 Mc; correction curve supplied

Wide Frequency Range without correction up to 120 Mc with maximum error of 10%; correction curve supplied

Single Zero Adjustment for all ranges

Equivalent A-C Input is a resistance in parallel with a capacitance; equivalent input capacitance of probe is 11 μμf; with plug connectors 12 μμf; equivalent parallel input resistance 7.7 megohms at low frequencies

Internal Calibration Control is a single adjustable resistor which corrects calibration if amplifier tube is changed

Auxiliary Connections supplied include a G-R double plug, pair of 30″ test leads, pair of test prods and two alligator clips

Lightweight only 9¼ pounds

Write for Complete Data

ADMITTANCE METERS ☆ COAXIAL ELEMENTS ☆ DECADE CAPACITORS
DECADE INDUCTORS ☆ DECADE RESISTORS
DISTORTION METERS ☆ FREQUENCY METERS
FREQUENCY STANDARDS ☆ GEIGER COUNTERS
IMPEDANCE BRIDGES ☆ MODULATION METERS
LIGHT METERS ☆ MEGOHMMETERS ☆ VARIACS
MOTOR CONTROLS ☆ PRECISION CAPACITORS
NOISE METERS ☆ NULL DETECTORS ☆ OSCILLATORS
POLARISCOPES ☆ PULSE GENERATORS
SIGNAL GENERATORS ☆ VIBRATION METERS
STROBOSCOPES ☆ U-H-F MEASURING EQUIPMENT
V-T VOLTMETERS ☆ WAVE ANALYZERS ☆ WAVE FILTERS

GENERAL RADIO Company

275 Massachusetts Avenue, Cambridge 39, Massachusetts

90 West St., NEW YORK 6 · 920 S. Michigan Ave., CHICAGO 5 · 1000 N. Seward St., LOS ANGELES 38

Since 1915—Designers and Manufacturers of Electronic Test Equipment